CHAETETIDS AND THEIR PALAEOENVIRONMENT IN THE AMORET LIMESTONE MEMBER (DESMOINESIAN) OF LABETTE COUNTY, KANSAS

by

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INTRODUCTION

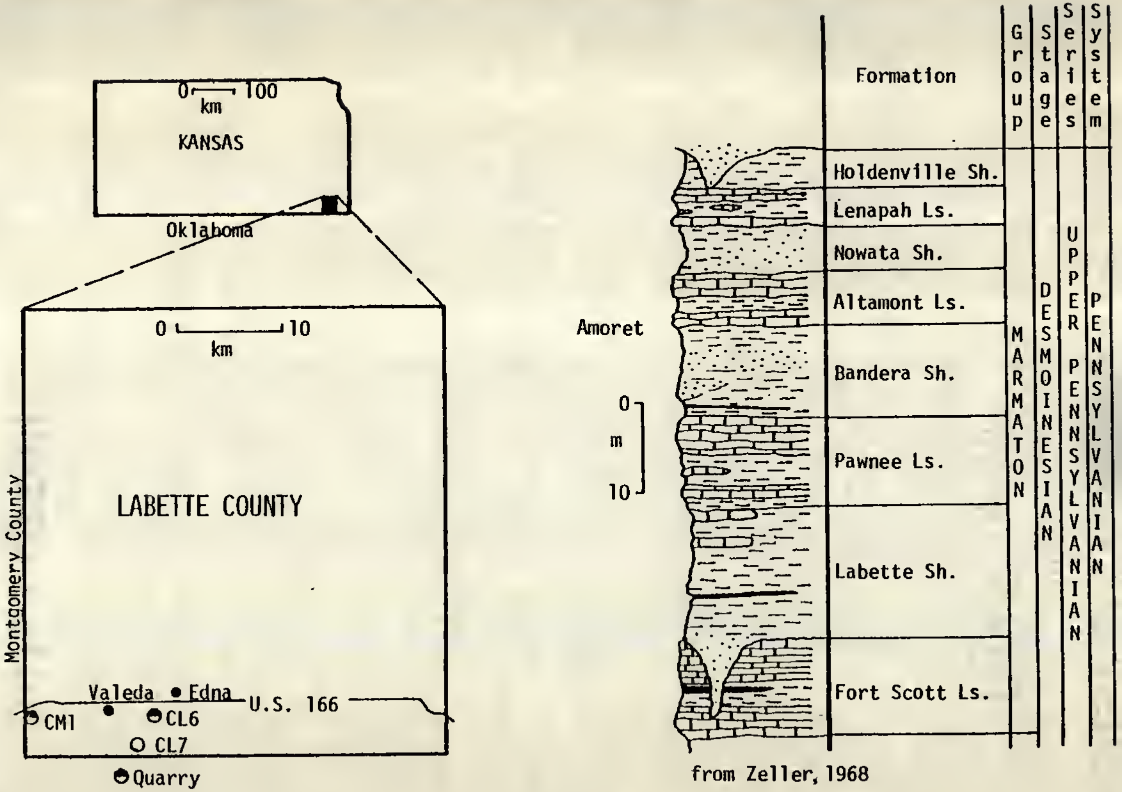
Purpose

Upper Desmoinesian (Marmaton) rocks in southeastern Kansas consist of shale and limestone that contain chaetetid bioherms (Jewett, 1945). A literature search revealed a paucity of information on chaetetids and associated depositional environments (palaeoenvironments) in these rocks. Moreover, information on chaetetids was controversial because Hartman and Goreau (1972) removed the chaetetids from the tabulate corals and assigned them to the order Chaetetida of the class Sclerospongiae (Porifera).

Three objectives of this investigation were: 1) to determine the general environmental setting and diagenetic characteristics of the three exposures of the Amoret Limestone Member of the Altamont Limestone that contain chaetetid build-ups, 2) to describe the external and internal morphology of chaetetids, and 3) to compare these chaetetids to extant sclerosponges. The Amoret Limestone Member of the Altamont Limestone Formation was selected because it contains: 1) well preserved chaetetids with distinctive features, and 2) a wide range of chaetetid growth forms.

Location

Three localities were chosen for detailed examination on the basis of: 1) completeness of section, 2) preservation and ease of collecting chaetetids, and 3) variation in chaetetid growth form. These sections are located in southwestern Labette County, Kansas. The western-most section (CM1) is an active quarry 0.15 km from the Labette-Montgomery county border and 4.8 km north of the Oklahoma border (fig. 1). Southeast of CM1 (9.7 km east and 4 km south), CL7 crops out in a drainage ditch along a county



from Zeller, 1968

Figure 1. Geographic Localities and Stratigraphic Sequence

road. An abandoned quarry 12 km east and 0.8 km south of CM1 is the site of CL6.

Previous Investigations

Sokolov (1962) reported that Fischer (1829) proposed and illustrated the genus *Chaetetes* and described two species: *C. fastigatus* and the genotype *C. cylindraceus*. Later, Fischer (1837) described six species of chaetetids: *C. excentricus*, *C. concentricus*, *C. dilatus*, *C. radians*, *C. cylindricus*, and *C. jubatus*. Because Fischer's descriptions were vague, chaetetid classification was based on the work of Milne-Edwards and Haime (1850) who ignored Fischer's work and designated *C. radians* as the genoholotype. Milne-Edwards and Haime (1850) considered chaetetids as members of the Favositidae (Suborder Zoantharia Tabulata).

Duncan (1872) recognized similarities between chaetetids and *Labechia* and reclassified both as alcyonarians. Lindstrom (1873) rejected these similarities, removed chaetetids from the coelenterates, and classified them as ectoprocts. Although Lindstrom was supported by Dollfus (1875), Zittel (1876), and Peterhans (1929), the chaetetid diagnosis of Lindstrom was based on characteristics of both coelenterates and ectoprocts. Before the turn of the century chaetetids were reclassified as hexacorals by Neumayer (1889) and Sturve (1898).

In a series of articles from 1908 through 1912, Kirkpatrick discussed the similarities between *Merlia normani*, chaetetids and stromatoporoids. He inferred that all three were sponges with siliceous spicules and a calcareous basal skeleton.

In 1930 Smith and Lang revised the genus *Chaetetes* and influenced Okulitch (1936) who proposed that chaetetids be included in the subclass

Schizocoralla (class Anthozoa). Also in 1936, Oakley designated the type species of Chaetetes as C. cylindraceus from the Lower Carboniferous of Russia.

Weissermel (1937) continued the reclassification trend by placing chaetetids in the Chaetokorallen. Bassler (1950) classified them as tetracorals and Lecompte (1952) denied any affinities between chaetetids and algae, ectoprocts, or anthozoans.

Moore and Jeffords (1945) considered chaetetids to be tabulate corals, but felt that data were insufficient for accurate classification. They believed that chaetetids should be excluded from the ectoprocts because of the large diameters of individual calicles.

In the United States, Hill and Strumm (1956) strengthened classification of chaetetids as a family of the Tabulata. In Russia, Sokolov (1939, 1955, 1962), Tesakov (1960), and Fischer (1970), proposed that chaetetids were hydrozoans. Sokolov (1962) based his classification on: 1) morphological similarities between chaetetids and stromatoporoids, 2) similarities in geological histories of both, 3) absence of definite septa, and 4) the "unique" microstructure of the calicle walls.

Hartman (1969) and Hartman and Goreau (1966, 1970a, 1970b, 1972) made the most important contribution to the enigmatic classification of chaetetids. They erected the class Sclerospongiae (phylum Porifera), including the orders Chaetetida and Ceratoporellida, and discussed the relationship between sclerosponges, chaetetids and stromatoporoids. This assignment was based on the rediscovery of Ceratoporella nicholsoni and five other sclerosponges from Jamaica which possessed characteristics similar to chaetetids and stromatoporoids.

Before Hartman and Goreau formally proposed this reclassification in

1972, Lustig (1971) made a detailed study of chaetetids from the Bird Springs Formation (Atokan) of southern Nevada. Lustig (1971) believed that the Pennsylvanian chaetetids of the Great Basin were not closely related to the sclerosponges because: 1) chaetetids possessed larger calicles, 2) lower portions of sclerosponge calicles are filled with additional calcium carbonate, 3) neophragma, essential to astogenetic development, are lacking in sclerosponges, and 4) sclerosponge calicles do not increase in diameter throughout their length. Since her work, these differences have been resolved (Hartman and Goreau, 1972, 1975).

Stearn (1972, p. 336) compared sclerosponges with stromatoporoids and concluded that stromatoporoids, archaeocyathids, and chaetetids, "...are in the evolutionary plexus between Porifera and Coelenterata". However, comparing stromatoporoids with *Merlia* and *Astrosclera*, Stearn (1975) presented an excellent reconstruction of stromatoporoid soft parts which applies equally well for chaetetids.

Hartman and Goreau (1975) described a new living sclerosponge, *Acanthochaetetes wellsi* and placed it with the Jurassic and Cretaceous fossils *A. ramulosus* and *A. seunesu* in a newly erected order Tabulospongida. Close similarities between these fossils and extant sclerosponges have more firmly established chaetetids as members of the Sclerospongiae.

Chaetetes was cosmopolitan in distribution during the Pennsylvanian (Upper Carboniferous); it has been reported in Russia, Japan, Tibet, Siberia, Egypt and the United States (Bassler, 1950). Lustig gave an excellent summary of occurrences in the Great Basin and Cordilleran.

In the mid-continent, Moore and Jeffords (1945) described new species of chaetetids from the Marble Falls Limestone (Lower Pennsylvanian) of Texas and the Hale Formation (Morrowan of Oklahoma. Jewett (1945) reported chaetetids in the Marmaton limestones of Oklahoma, Kansas and Missouri, and De Vries (1955) made a detailed study of a chaetetid "reef" in the Amoret Limestone Member of Iowa.

Jewett (1941) and Jungmenn (1964) reported that the Amoret Limestone in Labette County, Kansas contained chaetetid colonies and that local thickening (maximum of five meters) resulted from chaetetid bioherms.

METHODS OF INVESTIGATION

Field Procedures

Reconnaissance.-- Correlation of the Amoret Limestone Member of the Altamont Limestone along its outcrop (fig. 2) is the result of work by Cline (1941), Jewett (1945), Cade (1952), Faucette (1954), and Schenk (1963, 1967). In this study the Amoret Limestone was examined from Grundy County, Missouri, to Nowata County, Oklahoma but the major effort was concentrated on exposures in Neosho and Labette Counties, Kansas. In these two counties twelve sections were measured and three (in an area of extensive chaetetid build-up in Labette County) were chosen fcr detailed study (fig. 1). Because complete sections of the Amoret Limestone were not exposed at these localities, three cores (2.5 cm in diameter) were taken (using a core drill powered by a Homelite two cycle engine manufactured by J. K. Smit and Sons, Limited) to determine the total thickness of the Amoret. The basal contact at CM1 and the upper contact of the Amoret Limestone at CL7 were obtained by coring. Unfortunately the lower contact of the Amoret at CL7 was not found even though a 3.24 m core was obtained.

Stratigraphic Description.-- Exposures (and cores) of the Amoret Limestone were measured, described and subdivided into beds (Appendix I).

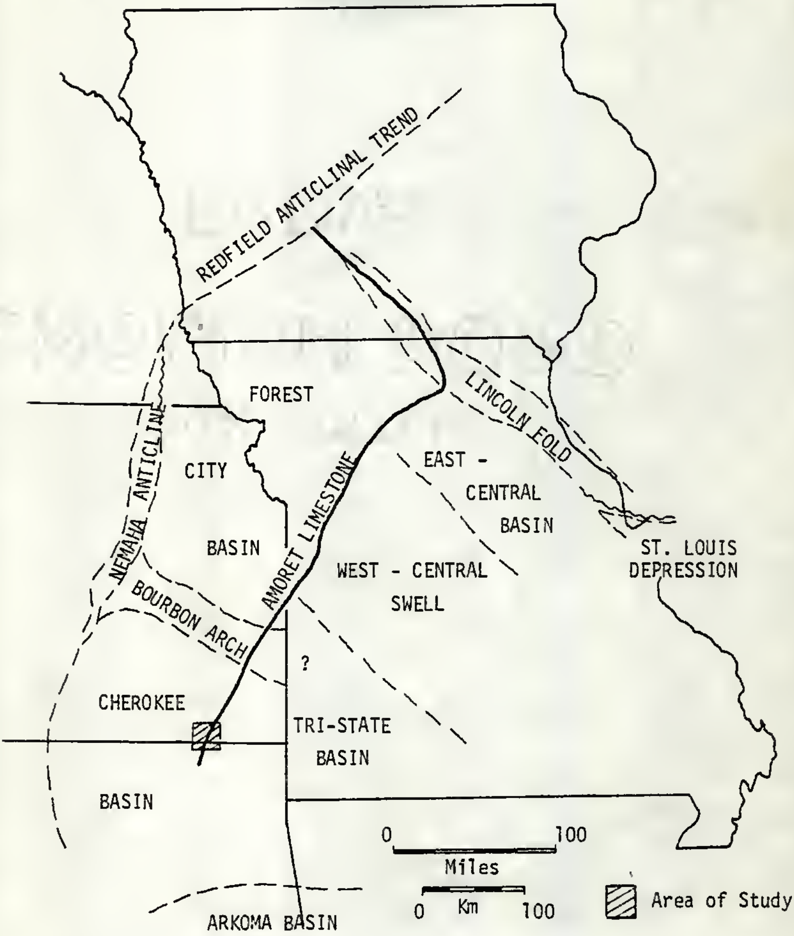


Figure 2. Outcrop of the Amoret Limestone Member of the Altamont Limestone Formation (modified from Schenk, 1963).

Criteria for subdivision were: 1) lithology, 2) weathering characteristics, 3) fractures, 4) joints, 5) contacts, 6) bedding, 7) macrofossils, and 8) color of fresh and weathered surfaces. Elevations of the top and bottom of each section were determined using topographic maps and hand level.

Collection of Samples.-- Samples of each bed in the Amoret Limestone were collected. Each sample was labeled and the "up" direction indicated. The best preserved chaetetids were found *in situ* and as float from a shale bed in the upper part of the Amoret Limestone at CM1. Many of these, especially those in early stages of development and with distinctive surface features, were sampled for studies of chaetetid structure and growth. In a fresh exposure of the top surface of this shale (at CM1) all the oncolites in a square meter were collected to determine variation in size and shape. Other oncolites from this quarry with unusual forms, large size, or chaetetid encrustations were collected separately.

Laboratory Procedures

General Statement.-- Two slabs (1 cm thick) were cut from bulk limestone samples oriented perpendicular to bedding. One was trimmed (1" X 3") for thin sections, the other was crushed for x-ray diffraction and insoluble residue analysis. Cores were slabbed and intervals representing major lithologic divisions were prepared in the same way.

X-ray Diffraction Analysis.-- Crushed samples and cores were sieved through a 230 mesh sieve, pressed into aluminum holders and covered on the underside with a coverglass and tape. All samples were scanned from 62 to 0 degrees two theta at a scale factor of 1000 and from 32 to 26 degrees two theta at a scale factor of 5000. Instrument settings for the Norelco Wide Range Diffractometer with 1.5405 angstrom wavelength, nickel filtered, copper Kα radiation were those given by Scott (1973, p. 14).

The calcite-quartz ratio, calcite-dolomite ratio, percent magnesium carbonate in calcite and mole percent calcium in dolomite were calculated according to procedures discussed by Goldschmidt, et al.(1955) and Blatt, et al. (1972) (Appendix II).

Insoluble Residue Analysis.-- A rough estimate of the percent acid insoluble residue was determined. Approximately three grams (weighed to four decimal places) of crushed, pea size rock were added to a preweighed 150 ml beaker. Dilute (.1N) hydrochloric acid was added and stirred with a magnetic stirrer until effervescence ceased. This solution was centrifuged, supernatant discarded, and the residue repeatedly washed and centrifuged at 2100 rpm for fifteen to twenty minutes until the supernatant was neutral. After the final washing, the residue was dried in an oven at 80° C, weighed, and the percent insoluble calculated (Appendix II).

Thin Section Analysis.-- Thirty-five thin sections were made using Petropoxy 154 adhesive. Slides were divided into three groups: 1) those from all samples of CM1 and representative samples of major beds at CL6, 2) those from the remaining samples of CL7 and CL6, and 3) those of chaetetids and oncolites.

Approximately 1400 points were counted on each of 18 slides of group 1 using the method described by Chayes (1949). Methods used in point counting slides of group 2 are described in Appendix III.

Recorded parameters included calcite grain size, allochem size and classification (i.e. organic vs. inorganic constituents), textural maturity, and extent of recrystallization. Calcite grains were divided by size into three groups: 1) less than four microns, 2) four to twenty microns, and 3) greater than twenty microns. These three categories are a modification by Twiss (1976, pers. comm.) of the classification proposed by Folk (1974). Percentages of these constituents were calculated and each slide was classified according to Folk (1974) (Appendix III).

Calicle dimensions and organization, wall thickness and microstructure, and diagenetic effects were recorded from thin sections of chaetetids (group 3).

Scanning Electron Microscopy.-- Chips (2 cm^3) oriented either parallel or perpendicular to the long axis of calicles were cut from chaetetid skeletons. After polishing with 400 and 600 grinding compound these chips were etched in 1.2 N hydrochloric acid for one minute and glued to posts for analysis on an ETEC Autoscan Model U1 scanning electron microscope.

Peels.-- Peels of chaetetids and oncolites were prepared following the method described by Stewart and Taylor (1965). Type of nucleus, calicle dimensions, tabulae spacing, clay mineral distribution and extent of silicification were observed and recorded from the least distorted peels.

Polished Surfaces.-- Vertical slabs of chaetetids and cores were polished with 400 and 600 silicon carbide powder. Surfaces were cleaned, dried, and sprayed with a clear acrylic spray (Krylon 1303). Calicle dimensions and arrangement, tabulae spacing, fractures, borings, growth bands, interruption partings and type of substrate were observed and recorded from these surfaces.

Sieve Analysis.-- Oncolites collected from CM1 were sieved using the standard sedimentological procedure described by Folk (1974). Weights of oncolites retained on each sieve were recorded and standard sedimentological parameters calculated (Appendix IV).

GEOLOGIC SETTING

Structure

The depositional environment of the Amoret Limestone Member of the Altamont Limestone along its outcrop was influenced by eight major features (Schenk, 1963): 1) the Redfield Anticline, 2) the Lincoln Fold, 3) the Forest City Basin, 4) the Bourbon Arch, 5) the Tri-State Basin, 6) the West-Central Swell, 7) the Cherokee Basin, and B) the East-Central Basin (fig. 2). The study area lies within the Cherokee Basin which was separated from the Forest City Basin by the Bourbon Arch until Mid-Cherokee time when sediments from the north and south met and overlapped (Jewett, 1951). Lee (1943, p. B5) described the Bourbon Arch as a northwest-southeast trending, low structural feature.

Stratigraphy

Cline (1941) proposed the name Tina Limestone Member for the lower limestone of the Altamont Formation. The type section of the Tina was later discovered to be the Higgensville Limestone Member of the Fort Scott Limestone Formation and Cline (1950) proposed the name Amoret as a substitute.

Jewett (1945) considered the upper, middle, and lower Amoret Limestone as three of the four cyclothems which comprise the Altamont megacyclothem. However, Schenk (1963) demonstrated that lithologic and biotic changes were related to structural features as evidenced by facies relationships and cyclic sedimentation. He proposed that the Altamont Limestone Formation represented only one cyclothem which was a result of eustatic change in sea level rather than diastrophism.

The interval studied in this report consists of two limestones separated by nine to 24 cm of oncolitic calcareous shale (fig. 3). At these three localities (CM1, CL6 and CL7) the Amoret ranges from nearly four to six meters in thickness, thinning westward. There is a gradational contact with the Bandera Shale Formation below and the Lake Neosho Shale Member above at CM1 and CL7. At CL6 there is a sharp contact with the Lake Neosho Shale Member above but the contact with the Bandera Shale Formation was not observed.

INTERPRETATION OF LABORATORY DATA

General Statement

Each section was subdivided into facies using: 1) lithology, 2) insoluble residue, 3) calcite-quartz or calcite-dolomite ratios, 4) energy index, 5) skeletal grain size, and 6) biotic content as criteria. A modification of the energy index of Leighton and Pendexter (1962) and Schenk (1963) was calculated from the ratio:

$$\frac{\%\ \text{allochems} + \%\ \text{insoluble residue}}{\%\ \text{micrite} + \%\ \text{microspar}}$$

Insoluble residue was used in the numerator because clay minerals and microquartz could not be identified in thin sections. Microspar was used in the denominator because it is the product of recrystallization of micrite (Folk, 1974). Using these lithologic and biotic data, four facies were recognized. In ascending order these facies are: 1) transition, 2) chaetetid-algal, 3) burrowed dolomite, and 4) oncolite-brachiopod.

Locality CM1

General Description.-- This section consists of two limestones separated by nine centimeters of calcareous shale. Total thickness of the

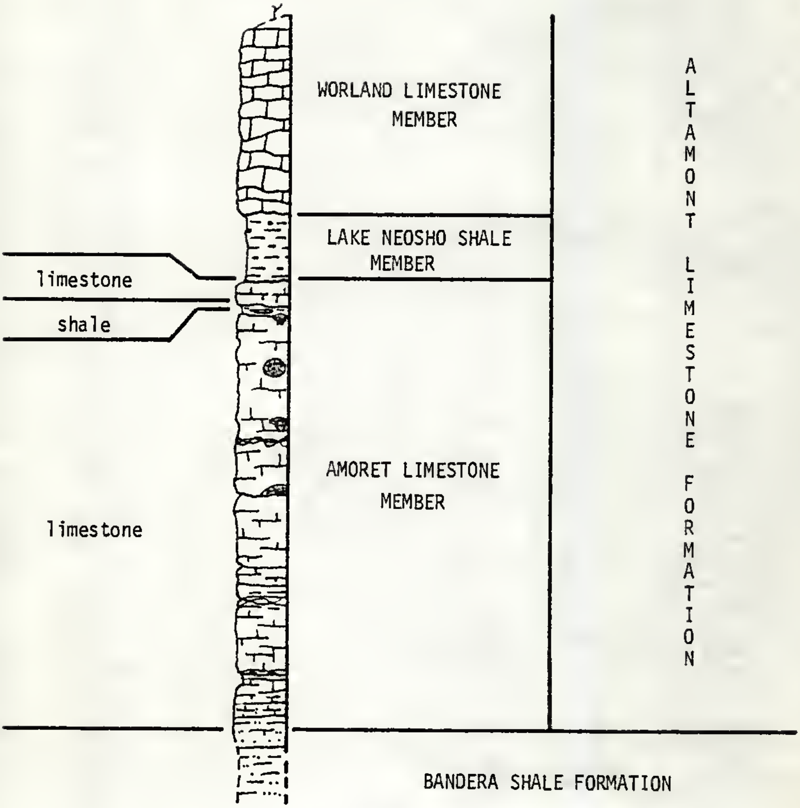


Figure 3. Generalized Stratigraphic Section

Amoret Limestone Member is 3.90 meters. The lower contact with the Bandera Shale Formation is gradational and the upper contact with the Lake Neosho Shale Member is sharp.

Lithologic Data.-- The energy index, insoluble residue, and calcite-dolomite ratio were most useful in recognizing facies (fig. 4). Insoluble residues were high (63.5 and B9.1 percent) at the base and top of the Amoret Limestone and less than 10 percent in the middle. Low calcite-dolomite ratios at the top suggest dolomitization. On the basis of Folk's (1974) criteria this is interpreted as secondary because: 1) rhombs are coarser than D.015 mm, 2) rhombs transect skeletal grain boundaries, and 3) dolomitization occurs in vugs and pore spaces between lithic fragments (Plate 1, figs. 1 & 2). Energy indices are low at the base, increase in the lower third, decrease and stabilizing toward the top. The high index (1.B) in the lower third occurs at the argillaceous organic partings. Neomorphic features include; 1) recrystallized algal fragments, 2) increased calcite grain size, and 3) replacement of skeletal debris and voids filled with quartz, microquartz and chalcedony.

Biotic Data.-- Skeletal grain size and biotic content, supplemented by field notes on chaetetid density and distribution aided in recognizing facies.

Biota include: the brachiopods Derbyia, Composita, Mesolobus, Kozlowskia, Neochonetes, Neospirifer, ostracodes, encrusting ectoprocts and Prismopora, crinoids, echinoids, the phylloid algae Ivanovia, Eugonophyllum, and Epimastopora, the foraminifers Endothyra, Endothyranella, Tuberitina, Hedraites, Tetrataxis, Globivalvulina and Apterrinella, calcispheres and spicules of uncertain affinities.

Burrowed Dsagia oncolites ($\frac{\text{SS-C}}{\text{LLH-C}}$ of Logan, et al., 1964) are the

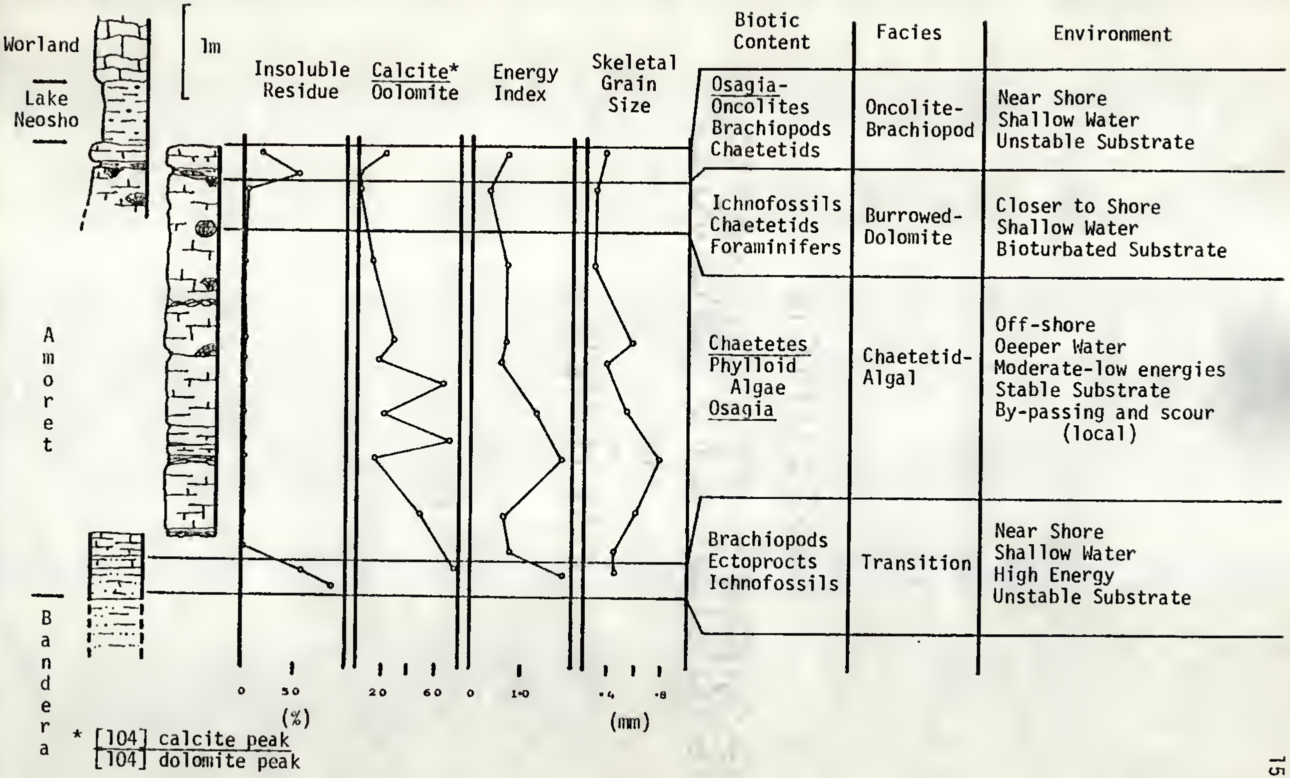


Figure 4. Facies at Locality CM1 of the Amoret Limestone Member of the Altamont Limestone Formation.

major component of the shale bed at the top of the Amoret Limestone Member (Plate 1, figs. 3 & 4). The modal size range of the oncolites is -4.0 phi with a median and graphic mean of -4.7 phi. Oncolite size ranges from 0.9 to 7.8 cm and is moderately well sorted (Appendix IV). Examination of 107 oncolites indicates that there are six different types of nuclei. Of these 107 oncolites, <u>Composita</u> formed the nucleus of 33, productaceans 14, spiriferaceans 4, lithic clasts 4, matrix coated grains 3, and unidentified skeletal fragments 49.

Encrusting chaetetids are present except at the base of the section. Sizes ranged from thin (one centimeter) laminae (shingles) to mounds 40 cm in diameter. Wide laminar bases occur on chaetetids which have encrusted oncolites. These chaetetid encrusted oncolites occur in shale at the top of the section. Several columnar chaetetids start in the limestone and continue through the shale and distort bedding adjacent to the chaetetid (Plate 1, fig. 4).

<u>Facies Interpretation</u>.-- Data obtained from this section demonstrate vertical differences in lithologic and biotic constituents. Trends in these data suggest that the Amoret Limestone can be subdivided into intervals with common characteristics which are interpreted as changes in the depositional environment (Plate 2, fig. 1).

Changes occur over a relatively short vertical distance (less than 1 m) at the base of the Amoret Limestone Member. Schenk (1963) suggested that these changes were a result of a rising sea level and the "retreat" of the Ozark Uplift delta as evidenced by sedimentological studies of the Bandera Shale Formation (Wanless, <u>et al</u>., 1963; Schenk, 1963). Wanless, <u>et al</u>., (1963) suggested that a laterally migrating delta moved around the Ozark Uplift and provided terrigenous clastics for pre-Amoret sediments.

Continued migration of this delta could have decreased terrigenous influx in this area at the end of Bandera time which would be reflected in the rock column by the gradational contact between the Bandera Shale and the Amoret Limestone. Decreasing terrigenous influence and increased carbonate deposition is also supported by lower percentages of insolubles and quartz grains. Upward decrease of the energy index suggests a transition to a quieter environment. Initial high energies (waves and currents) agitated quartz grains and biotic skeletons, thereby abrading and comminuting the softer calcite fragments, and washed out the "fines". Ichnofossils in the core samples are interpreted as evidence of endobionts. This lower part of the Amoret is interpreted as transitional between two depositional environments and is referred to as the transition facies (fig. 4).

The transition facies was followed by a more stable off-shore environment as evidenced by low energy indices and insoluble residues (low terrigenous components). Locally, scour and fill or tidal channels transected this area as evidenced by the large grain size, undulating organic partings and the high energy index peak above the transition facies (fig. 4). Chaetetids, phylloid algae and _Osagia_ dominate the biota. Large algal blades (up to 3 cm long) and chaetetid mounds (up to 60 cm in diameter) suggest that algae have stabilized the substrate for chaetetid growth. Algae could have also acted as a baffle trapping pelloids and _Osagia_-coated grains. Because phylloid algae, _Osagia_, and chaetetids dominate the biota, this facies is called the chaetetid-algal facies.

Fluctuations of the Ozark Uplift delta at the end of this time, decreased wave base (decreased sea level) resulting in higher energies. Field evidence (Appendix I) and thin section analysis indicate that a high energy index was not obtained because burrowing or boring organisms (Plate 3, fig. 2) destroyed large skeletal grains and sedimentary structures, homogenizing the sediment. Broken lithic fragments and more insolubles suggest higher energies and an increase in terrigenous detritus. As sediments became lithified, boring or burrowing organisms increased porosity (Plate 3, figs. 1-3). Pores and vugs produced by these activities were later filled with calcite and then replaced by dolomite. This is evidenced by boring or burrowing structures in the outcrop and low calcite-dolomite ratios. Together all these features characterize the burrowed-dolomite facies.

Assuming an Ozark Uplift delta, its shifting could have: 1) increased energies which broke lithified sediments and abraded skeletal fragments, and 2) increased clay mineral deposition in this area of southwestern Labette County. This is supported by high insoluble residues and the brecciated upper contact of the burrowed-dolomite facies (Plate 3, fig.3). Brachiopods, Osagia-coated skeletal fragments, and chaetetids with broad bases (encrusting oncolites) dominate the biota. These broad bases stabilized the chaetetids in this "higher" energy environment permitting upward growth. Observation of chaetetids and oncolites in outcrop support this interpretation (Plate 3, fig. 4). Upward, energies, oncolite production and the amount of clay minerals decrease with carbonate deposition dominating (fig. 4). Because brachiopods dominated the biota and oncolites are even more conspicuous, this facies is referred to as the oncolite-brachiopod facies.

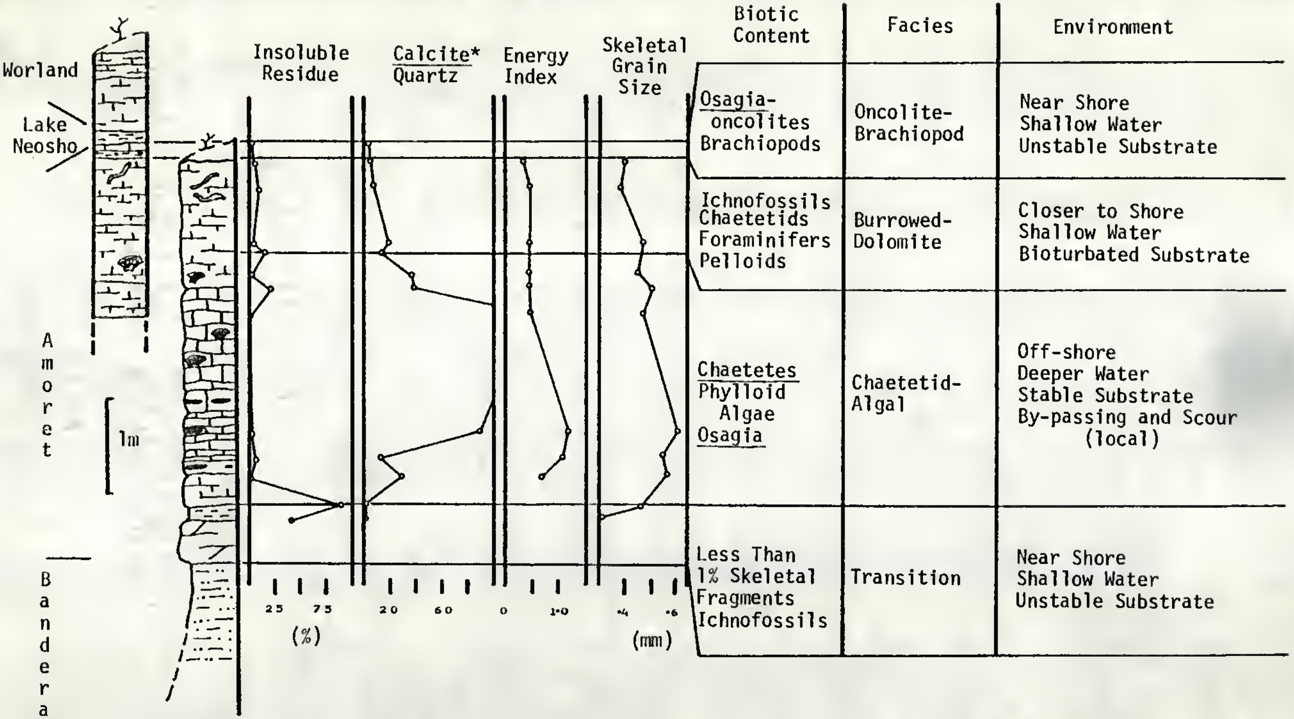
Locality CL7

General Description.-- The basal unit of the Amoret Limestone Member at CL7 is a silty dolomite overlain by 17.5 centimeters of mudstone. Associated organisms and mineralogy of the overlying carbonates are not unlike those at CM1. Total thickness of the Amoret Limestone is 4.05 m with a 5.5 cm shale separating the two limestones.

Lithologic Data.-- Calcite-quartz ratios, insoluble residues, and energy indices define facies (fig. 5). Insoluble residues are high (90 percent) at the base and low (less than 25 percent) in the middle. Because dolomitization is minor, calcite-quartz ratios are more meaningful. This ratio was low (less than 30) at the base and top but high (over 90) in the middle. Energy indices increase toward the middle, decreasing upward. Neomorphic features are the same as at CM1.

Biotic Data.-- Biotic associations are compatible with those at CM1. One oncolite (3.5 cm in diameter) with a *Composita* nucleus, was obtained from a core of the upper part of the section. The oncolitic shale is only 5.5 cm thick at this locality and unfortunately was lost in coring. Grain size increases from the base to the middle and gradually decreases toward the top. *Chaetetes* is absent at the base but abundant (up to 60 percent of the biota) in the remainder of the section. Small columnar chaetetids (10 cm in diameter and 20 cm in height) occur closely spaced but appear to have a patchy distribution.

Facies Interpretation.-- Interpretations of facies are generally the same as those for CM1. The transition facies is thicker (by approximately 20 cm) and is represented by a silty dolomite and mudstone. The dolomite contains subangular to angular quartz grains (averaging 0.025 mm in size) and dolomite rhombs (averaging 0.035 mm in size) (Plate 3, figs. 5-6). Few (less than one percent) skeletal grains were observed in thin section. Dolomite in this bed is interpreted as secondary because rhombs: 1) are



$*\frac{[104]\ \text{calcite peak height}}{[101]\ \text{quartz peak height}}$

Figure 5. Facies at Locality CL 7 of the Amoret Limestone Member of the Altamont Limestone Formation.

euhedral, 2) transect ostracode grains, 3) contain inclusions, and 4) average 0.035 mm in size (conforming to criteria proposed by Folk, 1974).

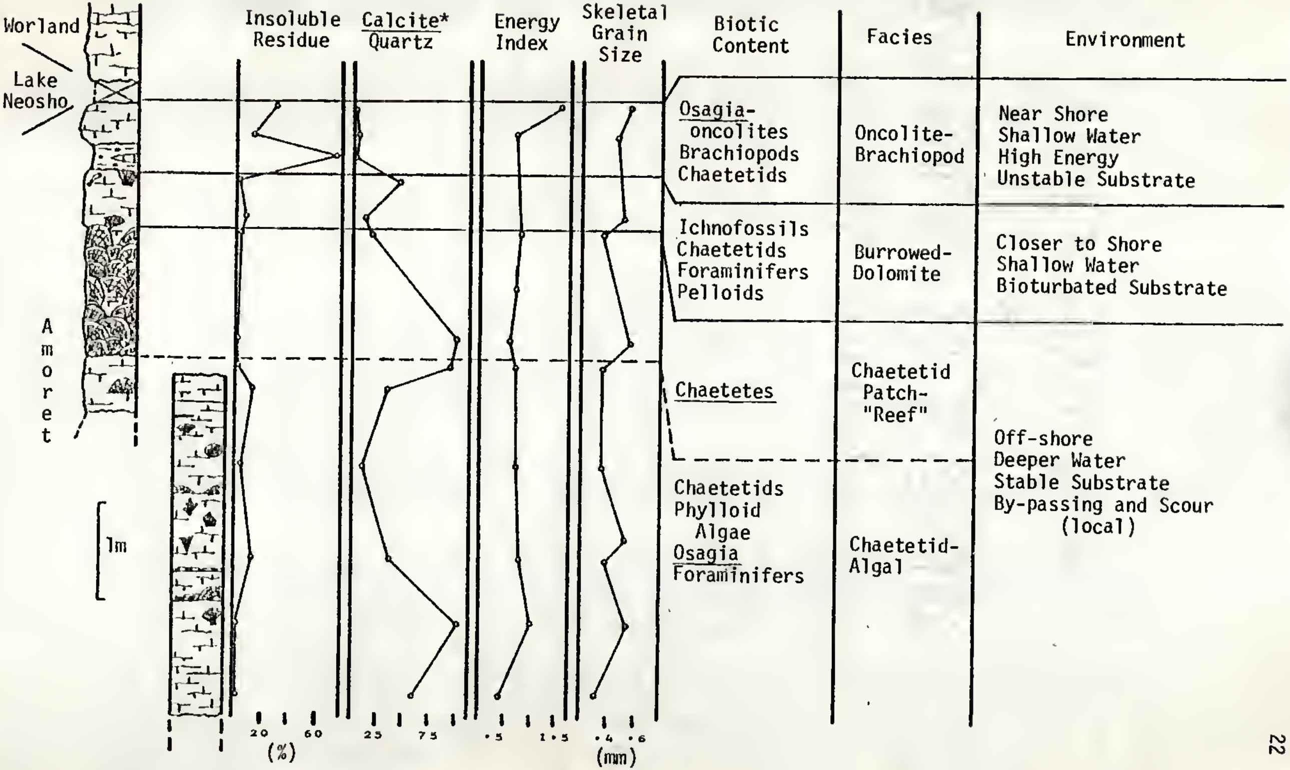
The contact between the transition and chaetetid-algal facies is sharp. Fluctuations in insoluble residues, not observed in CM1, are believed due to chert nodules and lenses and selective silicification within this interval. This is supported by the observation of quartz, microquartz and chalcedony in thin sections and insoluble residues. Energy indices, skeletal grain sizes and biotic constituents compare favorably to those at CM1.

The lower contact of the burrowed-dolomite facies is gradational and arbitrarily set at fluctuations in insoluble residue and the calcite-quartz ratio. This facies is easily recognized in the field because the burrowing features (Plate 4, fig.1) are accentuated by weathering. Dolomite was not observed in x-ray diffraction analysis of samples collected from the outcrop, but was found in the core of an equivalent interval (unit D, CL7, Appendix I).

The oncolite-brachiopod facies was not observed in outcrop but was recognized in the core. This facies is 13 cm thick (17 cm less than at CM1) but could not be studied in detail due to incomplete recovery of the core. The lower contact seems to be sharp but further observations were inconclusive.

Locality CL6

General Description.-- This section consists of two limestones separated by a 25 cm thick oncolitic shale. Although total thickness was greater (over 6.16 m), associated organisms, lithologic characteristics and facies differ little from localities CL7 and CM1 (fig. 6).



*[104] calcite peak height / [101] quartz peak height

Figure 6. Facies at Locality CL6 of the Amoret Limestone Member of the Altamont Limestone Formation.

Lithologic Data.-- Insoluble residues are low (with minor fluctuations in the middle) and increase to a high of 79.7 percent at the top. Calcite-quartz ratios fluctuate irregularly throughout the section while energy indices remain relatively stable (near 1.0) with a high value at the top.

Biotic Data.-- Associated organisms differ from the other localities in absolute percentages (Appendix III), but relative abundances of all except chaetetids are similar to CM1 and CL7. *Osagia* oncolites are similar in abundance and structure to those at CM1 but the oncolitic shale is 25 cm thick, compared to about 9 cm at CM1. Bioturbation below the shale is not as well developed as at the other two localities.

Mound-like accumulations of chaetetids (1.23 m thick) occurs about half a meter below the shale (Plate 2, fig. 2). However, there are columns that extend from the base of this interval to the overlying shale, reaching heights of up to two meters. Fractures and joints oriented N20°W (from 9-19 cm apart) are observed in both the chaetetid build-up and surrounding micrite. These fractures are filled with micrite or sparry calcite. Whereas grain size fluctuates in the lower and upper part of this sequence, there is a general decrease upward.

Facies Interpretation.-- The transition facies was not observed despite an attempt to core the Amoret-Bandera contact.

Insoluble residues, calcite-quartz ratios, grain size and biotic constituents of the chaetetid-algal facies are not unlike those at CM1 and CL7. Two obvious differences are: 1) the increased thickness (4.05 m), and 2) the chaetetid build-up. At the top of this facies chaetetids comprise up to 95 percent of the biota and form a structure in cross section not unlike some patch reefs behind the Florida Reef Tract. Columnar chaetetids occupy the core of this complex with mound chaetetids around the periphery.

This reef-like structure tapers laterally and pinches out along the southern face of the quarry (Plate 2, fig. 2). Although insoluble residues and energy indices remain stable, calcite-quartz ratios and grain size of associated organisms decrease toward the top of this facies.

The sharp contact at the top of this build-up defined the lower boundary of the burrowed-dolomite facies. Low insoluble residues, energy indices, biotic constituents, burrowing structures and visual appearance are similar to those seen in this facies, at CM1, and at CL7. Dolomite is absent and calcite-quartz ratios are compatible with values from this facies at the other localities. Grain sizes at CM1 and CL7 are smaller than those observed in this locality.

The overlying shale and limestone comprise the oncolite-brachiopod facies. Lithologic and biotic data are compatible with those of the other sections. The only difference in this facies from its counterparts at CL7 and CM1 is its greater thickness (0.61 m, compared to 0.13 m at CL7 and 0.30 m at CM1).

INTEGRATION OF DATA

General Statement

Data obtained at these three localities allow lateral as well as vertical interpretations of depositional environment and facies relationships. Emphasis will be placed on anomalies between sections to interpret variations in general depositional environments within facies.

Transition Facies

The relationship between this facies at the three localities is shown in figure 7. Decreasing energy indices and insoluble residues

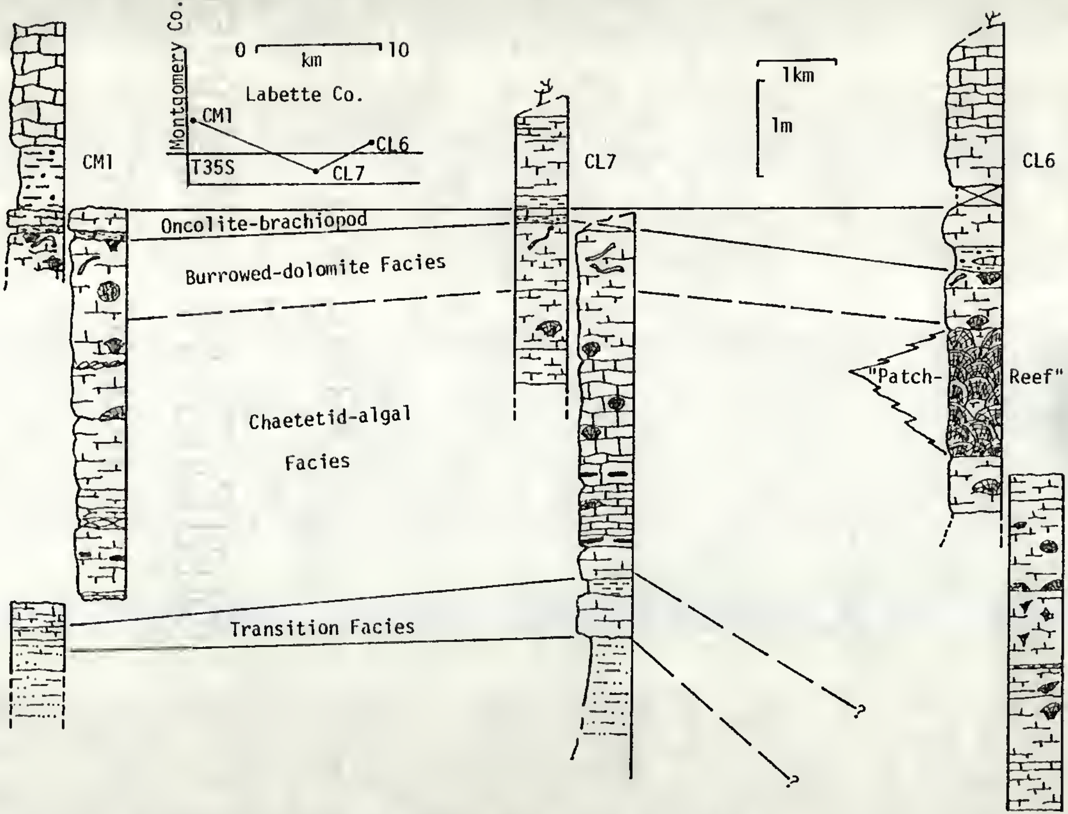


Figure 7. Correlation of Facies at Localities CM1, CL7, and CL6.

indicate that lateral migration of the Ozark Uplift delta decreased the influence of terrigenous clastics during early Amoret time. The lower transition facies at CL7 is represented by silty, quartz dolomite which was not observed at CM1. A replacement origin of dolomite, as proposed by Folk (1974),is interpreted from: 1) the transection of skeletal grain boundaries by dolomite rhombs, 2) the euhedral shape of rhombs, 3) inclusions, and 4) rhomb sizes averaging 0.035 mm. Absence of dolomite in basal Amoret exposures in adjacent areas suggests that this was a localized occurrence. The mechanism of this dolomitization has not been determined. Models such as seepage refluxion (Adams and Rhodes, 1960) in restricted bays,tidal flats and desert playas are not supported by palaeoenvironmental interpretations. The absence of evaporites in field observations and x-ray analyses of associated lithologies suggests that hypersaline conditions did not occur at this time. Blatt, et al. (1972) cited an example of Holocene dolomitization in clay-rich sediments on the continental shelf off the Louisiana coast. They suggested that localized dolomitization occurred as a consequence of calcification of sodium smectite which raised Mg/Ca ratios of the water. X-ray analysis of associated clay minerals has not been undertaken so this mechanism of dolomitization can be neither supported nor negated. Subtidal Holocene dolomite in silty terrigenous muds of Baffin Bay, Texas has been reported by Behrens and Land (1972). They suggest that dolomite precipitated from bay waters having Mg/Ca ratios near that of normal sea water. These two examples indicate that dolomitization may occur in an environment similar to that postulated for the transition facies.

The shale at the top of this facies at CL7 suggests that fluctuations in the position of the delta may have deposited fine grained sediment in areas closer to shore. On the other hand, Jewett (1945) suggested that the basal Amoret represents a time of scour and fill and sedimentary bypass. If this occurred, localized deposition at locality CL7 could account for this shale. Little evidence has been obtained to support these hypotheses and a definite interpretation at this time would be speculative.

The low content of skeletal grains may be a result of: 1) turbid conditions, 2) low numbers of skeletal bearing epibionts, and (or) 3) abrading and washing away of skeletal debris. The absence of chaetetids at this time may be a result of the fluctuating environment, loose unstable substrate and turbid conditions.

Lithologic data from the transition facies indicate a sequence of: 1) deposition of silty carbonate mud at CM1 and secondary influx of quartz silt and clay minerals at CL7, 2) burial of these sediments, and 3) diagenesis, including a) dolomitization, and b) recrystallization.

Chaetetid-algal Facies

This facies represents a time of moderate to low energies, normal marine salinities and shallow water depths. Algae may have been transported into this area from a nearby source such as the Bourbon Arch as has been suggested by Schenk (1963) and evidenced by the large phylloid algal blades and lack of algae in life position at these three localities. The influence of algae on Pennsylvanian sedimentation has been well documented by Wray (1959), Harbaugh, et al. (1965), Heckel and Cocke (1969), and Toomey and Winland (1973). Ginsburg and Lowenstam (1958) and Turmel and Swanson (1976) have discussed the influence of algae on the depositional environment of recent sediments in the Florida Keys and emphasized "build-ups" such as Rodriguez Bank whose principal sediment contributors are algae. Ball, et al. (1977) reported that phylloid algae were important sources of sediment rather than important builders. The dominance of chaetetids and phylloid algae, and the chaetetid mound form, suggests that algae may have modified the substrate by stabilizing it prior to chaetetid development. Pelloids and low energy indices indicate relatively calm water conditions but Osagia coatings indicate enough water movement for grains to be completely encrusted. The fact that Osagia ranks as the third most abundant organism suggests that the sea floor was within the photic zone. Chaetetids at CM1 and CL7 (forming mounds up to 60 cm in diameter and (or) columns up to 30 cm high) did not reach densities or the build-up stage exposed at CL6. This build-up (at the top of the chaetetid-algal facies) was a localized event as similar structures were not observed in the other two measured sections or during reconnaissance work. De Vries (1955) reported a similar occurrence in the Amoret Limestone Member of Iowa which was also localized. Fractures transecting chaetetids and the adjacent biomicrites, slickensides on chaetetid surfaces, and microstylolites may be a result of compaction and (in the case of the microstylolites) pressure solution. Distortion of bedding below the chaetetid build-up or in adjacent lithologies was not observed, suggesting that subsidence had not occurred. Other forms of evidence suggesting a lack of subsidence are the: 1) flat-lying limestone and shale beds (with no increase in thickness) directly over the chaetetid build-up, 2) lack of downwarping in beds adjacent to the build-up, 3) apparent horizontal base of this structure, and 4) consistency of bedding thickness laterally from the build-up.

The occurrence of two different chaetetid morphologies (columns in the center of the build-up and mounds around the periphery) is believed to have been a response to environmental factors such as crowding, competition or protection from wave energies but evidence to support this is inconclusive.

The sequence of events reflected by the chaetetid-algal facies is: 1) deposition of micrite and skeletal grains with little terrigenous influx, 2) lithification, 3) recrystallization, 4) deposition of sparry and drusy calcite,filling pores and calicles of chaetetids, 5) replacement and void filling of chaetetids before and after deposition of sparry and drusy calcite, and 6) minor dolomitization.

Burrowed-Dolomite Facies

Burrowing structures (Plate 3, figs. 1 & 2) observed in outcrop and thin section may be responsible for the destruction of sedimentary structures and increased porosity and permeability. Chaetetid growth occurred, but in concentrations lower than in the previously described facies. Energies were higher as evidenced by the finely comminuted and abraded skeletal debris and the occurrence of broken lithic fragments at the top of this facies. Anomalously low energy indices may be due to bioturbation and destruction of skeletal grains by burrowing organisms. These features suggest a decrease in wave base (shallower water) which could have resulted from the deltaic system of the Ozark Uplift shifting laterally so as to affect more directly this Labette County area. Secondary dolomitization, as evidenced by: 1) rhombs transecting skeletal grain boundaries, 2) euhedral shapes, and 3) dolomite occurring along fractures and in pore spaces, was found only at CM1 and in the core at CL7. Evidence for dedolomitization was not observed in thin sections of this facies at CL6 and therefore the lack of dolomite at this locality remains inexplicable.

The sequence of events as reflected in the burrowed-dolomite facies is: 1) deposition of micrite and skeletal debris, 2) modification of sediments by burrowing organisms, 3) lithification, 4) increase in porosity by brecciation and by boring and burrowing organisms, 5) infilling with sparry calcite of structures produced during (4), and 6) dolomitization.

Oncolite-Brachiopod Facies

This facies is well developed at all three localities. Oncolites indicate a high energy environment in the low intertidal to high subtidal zone. Logan, et al. (1964, p. 81) stated that this type of oncolite indicates:

> more or less continual motion which results in the growth of concentrically stacked spheroidal laminations. This type is probably restricted to areas continually under water and sufficiently agitated to permit almost continual motion of the spheroid.

Columnar chaetetids were observed in the field but laminar forms dominate the shale (Appendix I) suggesting that the laminar growth form did not require a stable substrate. Lack of substrate stability require the chaetetids to form a broad base to prevent sinking and (or) overturning.

The increase in insolubles and in thicknesses of the shale toward the east suggests that fluctuation of the Ozark Uplift delta may have deposited clay minerals with increasing thickness of sediments (clay minerals) closer to the source area. The limestone above the shale represents an increase in wave base (deeper water) and decrease in energy and terrigenous influx. Osagia-coated skeletal grains and small (less than 1 cm in diameter) oncolites suggests that there was enough energy to roll skeletal fragments but not enough energy to form larger (greater than 1 cm in diameter) concentrically laminated oncolites.

The sequence of events reflected in the oncolite-brachiopod facies is: 1) deposition of terrigenous detritus, skeletal debris and the formation of oncolites, 2) deposition of micrite above (1), 3) recrystallization of skeletal debris, 4) filling of pore spaces with sparry and drusy calcite, 5) filling and replacement by silica-rich solutions, 6) dolomitization.

CHAETETIDS

Preservation

The best preserved chaetetids possess calicle walls of calcite grains or fibers and calicle interiors (lumen) filled with anhedral sparry and euhedral drusy calcite (fig. 8A). Drusy calcite is used in the same sense as discussed by Illing (1954) and Dunham (1969) for euhedral calcite crystals lining a cavity with crystal elongation directed toward the center of a void (fig. 8A). Calicles in a single specimen were observed both with and without drusy calcite linings. In cross section drusy calcite forms euhedral, acicular crystals aligned perpendicular to calicle walls (Plate 4, fig. 2). Drusy calcite crystals in longitudinal sections of calicles are aligned in continuity with the fibroradial arrangement of the walls (fig. 8B).

The origin of the drusy calcite lining in Kansas chaetetids is unclear. Submarine cementation through the influence of biochemically controlled microenvironments has been suggested as a mechanism for drusy calcite deposition (Dunham, 1969). Lustig (1971) observed calcite in Atokan chaetetids and suggested an origin similar to that described by Dunham (1969). She believed that there was no evidence for subaerial exposure

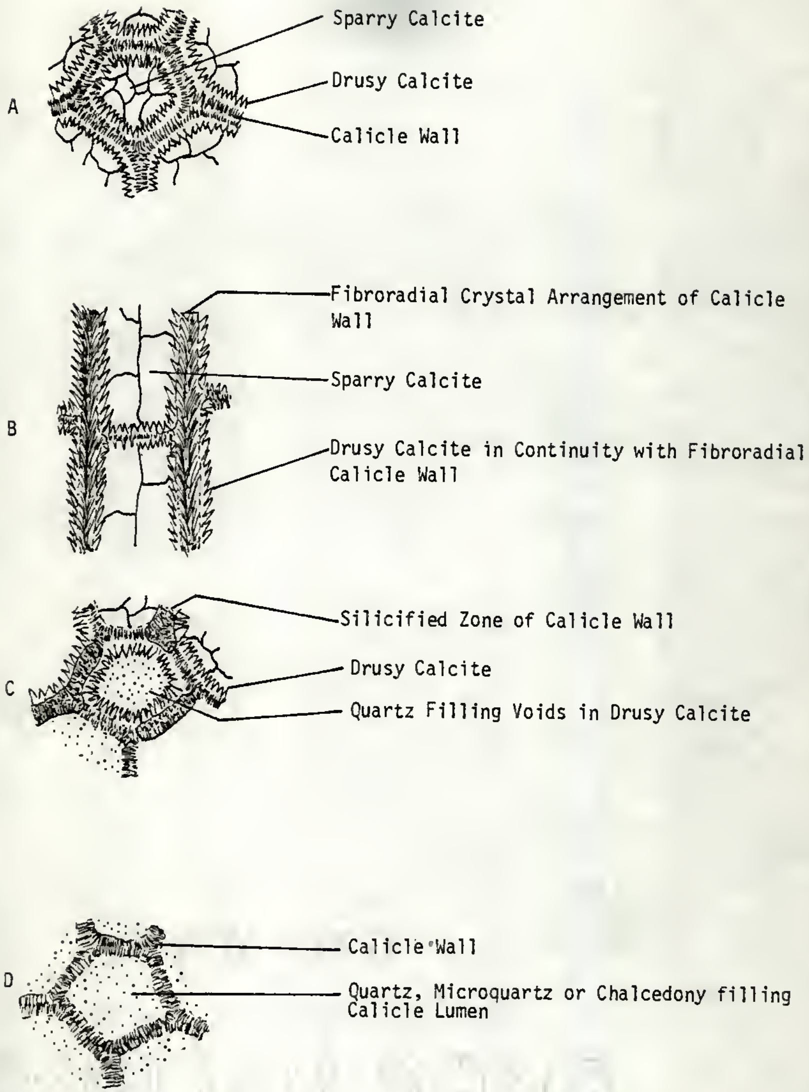


Figure 8. Typical Preservation of Chaetetid Microstructure.

of chaetetids prior to the formation of drusy calcite and that this type of calcite was deposited soon after death of the organism. No evidence has been observed which contradicts or supports Lustig's hypothesis for the origin of drusy calcite.

Deposition of drusy calcite is believed to be the first generation of calcite because it was observed lining calicle walls only. Voids left by the drusy calcite are filled with anhedral sparry calcite and in some calicles only sparry calcite fills the lumen. This would suggest that either the deposition of drusy calcite was selective (i.e. occurring only in restricted areas of the skeleton) or that anhedral sparry calcite replaced the drusy linings.

Other minerals observed in chaetetid skeletons were quartz, kaolinite, dolomite and pyrite. Silica was deposited as quartz, microquartz or chalcedony and occurs as: 1) complete silicification of calicle walls and tabulae with or without sparry calcite filling calicle interiors, 2) partial silicification with alternating silicified and non-silicified walls in the same calicle (fig. 8C), 3) filling of calicle lumina with quartz and no silicification of walls or tabulae (fig. 8D), or 4) one or more of the above.

Berner (1971) attributed the origin of silica-rich solutions to: 1) dissolution of diatoms or radiolarians, 2) dissolution of siliceous sponge spicules, and (or) 3) weathering of montmorillinite to kaolinite. All three of these could have been responsible for the quartz in Kansas chaetetids because: 1) radiolarians range from the Precambrian to Recent, 2) sponge spicules and pseudomorphs of sponge spicules were observed in thin sections (Plate 4, fig. 2), and 3) kaolinite was observed filling calicle lumina (Plate 4, fig. 2).

Pyrite was observed in close association with skeletal walls indicating that decomposition of the organic constituents may have produced reducing microenvironments favorable for pyritization.

Dolomite was indicated by x-ray diffraction analysis of a chaetetid skeleton but was not observed in thin section and is interpreted as replacement.

The paragenetic sequence of chaetetid mineralization is a modification of that proposed by Lustig (1971) and consists of the following seven events: 1) construction of the skeleton by the organism, 2) pyritization during decomposition of organic constituents, 3) deposition of drusy calcite, 4) deposition of anhedral sparry calcite, 5) deposition of quartz in voids, 6) selective silicification of calicle walls and tabulae, and 7) dolomitization. This sequence differs from Lustig's because she did not report pyrite in Atokan chaetetids.

Gross Morphology

Lustig (1971) gave an excellent description of Nevadan chaetetid morphology which is generally applicable to Kansas chaetetids. In the chaetetids collected for this study, three basic morphological types were observed: 1) shingles, 2) mounds, and 3) columns (Plate 5, figs. 1-4). Shingles consist of small laminar forms in which lateral dimensions are greater than vertical dimensions and the surface expression conforms to the topography of the substrate. This form is rare in the study area and is usually found on black fossiliferous organic partings or oncolites.

In chaetetid mounds, lateral dimensions equal vertical dimensions forming large hemispherical skeletons (Plate 5, fig. 3). The largest mounds (62 cm in diameter) occur at CL6 but larger mounds (up to 80 cm in diameter) were observed in outcrops in northern Labette County.

Vertical dimensions exceed lateral dimensions in columnar chaetetids (Plate 5, fig. 4). This form resembles a series of inverted, stacked bowls reaching heights up to 1.5 meters. The best-developed columnar chaetetids were observed at CL6 (Plate 2, fig. 2).

Bottjer (1976) considered stromatoporoids as sclerosponges and classified stromatoporoid geometric form as: 1) laminar, 2) hemispherical, 3) mamelonated, and 4) digitate. He noted that type 1 and 2 developed in areas where circulation was moderate to high. Type 2 developed on substrates that were more rigid than the substrate of type 1. Types 3 and 4 developed in areas of low circulation with the laminar or hemispherical forms being a function of sediment (substrate) plasticity. Spaw (1977) classified chaetetid skeletons as: 1) shingle-form (adapted to areas of frequent fluctuations in physical and biological environments) and 2) club-form (adapted to more stable, quiet, deep water conditions).

Mound and column-form chaetetids may be adaptations of the shingle forms to different environmental conditions. Field observations suggest that shingle forms dominated argillaceous (clayey) environments. The broader base of shingle chaetetids may be an attempt to increase surface area on a loose "fluidy" substrate (as postulated for the oncolite-brachiopod facies). With a stable, "firm" base, columns or mounds could develop by growth vertically at a rate greater than or equal to lateral growth (fig. 9). Mound chaetetids are characteristic of "cleaner" carbonate environments. Phylloid algae and Osagia occurring in less turbid waters may have stabilized the substrate for chaetetid growth (as interpreted for the chaetetid-algal facies). The columnar growth form may be a response to some of the factors suggested by Lustig (1971), Bottjer

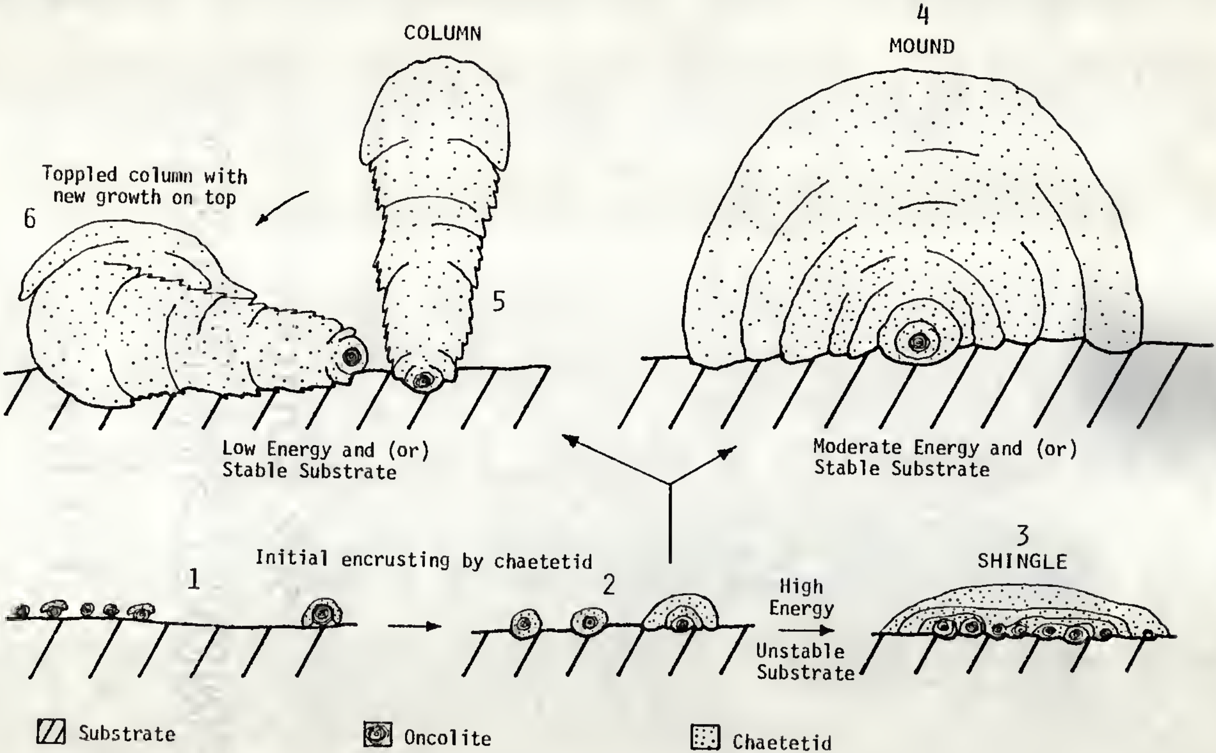


Figure 9. An Interpretation of Chaetetid Development and Palaeoenvironment

(1976), and Spaw (1977), or simply a response to crowding. Columnar forms are only observed in areas where densities of organisms (or oncolites) were high as in: 1) patches of columnar forms at CL7 where columns of chaetetids occur in the core of the build-up, and 3) areas where oncolites are abundant. Where chaetetids are closely spaced, lateral growth may be inhibited by adjacent chaetetids. This may also occur in the oncolite-brachiopod facies where abrasion or collisions of oncolites or skeletal fragments with the chaetetid could hinder lateral tissue development and thus vertical growth would take precedence over lateral growth.

Other factors (e.g. incurrent-excurrent mixing rates, circulation, substrate plasticity, and sedimentation rates) probably affected chaetetid external morphology but detailed investigations into these processes were beyond the scope of this study.

Calicle Characteristics

Chaetetids at the three Kansas localities possess ceroid and, to a lesser extent, meandroid calicles with circular, polygonal, elliptical and irregularly-shaped transverse sections (Plate 6, figs. 1 & 2). Because few calicles were circular, measurements were made of both longest and shortest dimensions. Error was unavoidable in these measurements because of recrystallization and deposition of drusy calcite and other mineral fillings in calicle lumina which obscured calicle wall boundaries. The most useful criteria for determining the position of the walls appeared to be color and texture (the calicle walls were darker and finer grained) and these were used for most measurements. The long dimension ranged from 0.11 to 0.57 mm (averaging 0.33 mm) and the short dimension averaged 0.23 mm and ranged from 0.08 to 0.43 mm (Appendix V).

No dimorphism of calicles was observed with one possible exception. Linearly-arranged calicles (in two specimens) converge to a central point (Plate 6, fig. 6). Calicle division generally occurred perpendicular to the direction of elongation. This arrangement is related to the position of astrorhizae as will be discussed later.

Deformation occurred as a breakdown of circular, elliptical or polygonal calicles to an irregular or meandroid arrangement (Plate 6, fig. 1). This deformation was a result of the activity of other organisms (which will be discussed later) or deposition of skeletal debris on the chaetetid surface. Chaetetids appear to continue to grow and build calicles around and over skeletal debris, but a regular arrangement is not maintained.

Calicle Walls

Calicle walls are contiguous with no perforations or mural pores. Thin sections and SEM photographs show that the walls are not always smooth but could be undulatory or irregular (Plate 7, figs. 1 & 2). Wall thickness ranged from 0.03 to 0.16 mm averaging 0.07 mm (Table 1). Microstructure of calicle walls (in thin sections) was fibroradial (essentially synonomous with "trabecular", "fascicular", and "jet d'eau" of other authors; see Hartman and Goreau, 1972) (Plate 7, fig. 1), the same as in Atokan chaetetids (Lustig, 1971) and extant sclerosponges (Hartman and Goreau, 1972). SEM photographs showed that calicle walls consist of fine calcite grains but this could have resulted from etching during sample preparation or grain enlargement during recrystallization (Plate 7, fig. 2).

Determinations based on x-ray diffraction analyses, insoluble residues, peels, and thin sections indicate that these fossil chaetetids are composed of calcite, quartz, dolomite, pyrite and kaolinite. The mole percent of

Table 1

Wall Thickness of Twelve Chaetetids
Collected From Southeastern Kansas

Specimen Number	n	Average	Range
CM1-3	39	0.054 mm	0.031 - 0.092 mm
CM1-F3	22	0.085	0.061 - 0.122
CM1-5	20	0.082	0.051 - 0.102
CM1-F18	13	0.079	0.061 - 0.102
CM1-23	34	0.086	0.041 - 0.122
CM1-F25	8	0.074	0.043 - 0.159
CM1-F39	24	0.066	0.041 - 0.112
CM1-F42	5	0.063	0.041 - 0.092
CM1-F45	18	0.062	0.043 - 0.087
CL7-11	37	0.074	0.043 - 0.115
CL6-B	47	0.059	0.043 - 0.087
CL6-C	5	0.047	0.031 - 0.061
Total	272	0.831	

Average Wall Thickness of Specimens: 0.0696 mm

Range of Wall Thicknesses: 0.031 - 0.159 mm magnesium carbonate in calcite was eight-tenths of a percent and substitution (whether calcium, magnesium or ferric ions was not determined) in dolomite was 60.5 percent (Appendix III). The low mole percent of magnesium carbonate in calcite of chaetetid specimens indicates that the original skeletal walls were low-magnesium calcite or aragonite as suggested by Hartman and Goreau (1972).

Tabulae

Tabulae are complete, incomplete, concave, convex, or flat lying. They may be at the same level in adjacent calicles, irregularly spaced or absent altogether (Plate 7, figs. 3 & 4). Tabulae thicknesses range from 0.007 to 0.051 mm averaging 0.021 mm (Table 2). Spacings of tabulae range from 0.08 to 0.495 mm averaging 0.23 mm (Table 3). Lustig (1971, p. 36) stated:

> The gross distribution pattern of the tabulae within one or different colonies is so diverse, that the lack of uniformity must be attributed to diagenetic factors.

She also suggested that preservation of tabulae will depend on: 1) the original thickness, 2) crystal structure, 3) organic content, and 4) deposition of drusy calcite. Comparisons between Atokan chaetetids and the sclerosponge *Merlia normani* led Lustig (1971) to conclude that tabulae in chaetetids were not continuous with the structure of the walls as they are in *Merlia*. Thin sections and SEM photographs of Amoret chaetetids do not support her conclusions and show that tabulae are continuous with calicle walls (Plate 7, figs. 1 & 2).

Growth Bands

Growth bands were observed in 16 specimens and widths ranged from 0.09 to 0.86 cm per band (Table 4). Alternating light and dark coloration in

Table 2

Thickness of Tabulae in Ten Chaetetids
From Labette County, Kansas

Specimen Number	n	Average	Range
CM1-2	39	0.019 mm	0.007 - 0.029 mm
CM1-3	32	0.017	0.010 - 0.031
CM1-4	42	0.019	0.007 - 0.029
CM1-5	29	0.023	0.010 - 0.031
CM1-6	27	0.017	0.010 - 0.041
CM1-F18	23	0.026	0.010 - 0.041
CM1-F25	17	0.029	0.020 - 0.051
CM1-F39	12	0.018	0.014 - 0.028
CM1-8	31	0.021	0.010 - 0.041
CM1-F45	14	0.035	0.014 - 0.043
Total	266		

Average Thickness of Tabulae: 0.021

Range of Tabulae Thickness: 0.007 - 0.051

Table 3

Spacing of Tabulae in Chaetetids From Southeastern Kansas

Specimen Number	Number of Calicles	Average per Specimen	Range per Specimen
CM1-2	8	0.291 mm	0.199 - 0.351 mm
CM1-3	6	0.193	0.149 - 0.258
CM1-4	18	0.272	0.213 - 0.416
CM1-5	9	0.143	0.082 - 0.207
CM1-6	6	0.207	0.168 - 0.224
CM1-8	5	0.256	0.194 - 0.316
CM1-23	6	0.191	0.092 - 0.296
CM1-F18	1	0.300	-
CM1-F25	6	0.324	0.145 - 0.495
CM1-F39	3	0.284	0.229 - 0.336
CM1-F45	6	0.152	0.129 - 0.227
Total	74		

Average Spacing per Specimen: 0.234 mm

Range in Spacing: 0.082 - 0.459 mm

Table 4

Growth Band Width of
Eight Amoret Chaetetids (mm)

Specimen Number								
CM1-F9	CM1-20	CM1-F25	CM1-F25	CL7-9	CM1-F26	CM1-F29	CM1-F37	
0.46	0.27	0.40	0.58	0.22	0.62	0.36	0.56	
0.34	0.46	0.35	0.48	0.29	0.39	0.13	0.52	
0.20	0.23	0.41	0.26	0.35	0.21	0.20	0.79	
0.17	0.29	0.32	0.33	0.61	0.28	0.11	0.61	
0.22	0.31	0.36	0.19	0.25	0.24	0.39	0.58	
0.31	0.14	0.09	0.23	0.23	0.17	0.17	0.69	
0.27	0.10	0.26	0.24	0.26	0.10	0.20	0.65	
0.35	0.49		0.16		0.18			
	0.16		0.86		0.18			
	0.16		0.36		0.17			
	0.34		0.20		0.26			
	0.41				0.26			
					0.26			
					0.30			
0.29	0.28	0.31	0.35	0.31	0.26	0.22	0.56	avg.

calicle walls produced bands which were perpendicular to calicle elongation (Plate 7, fig. 5). Contacts between light and dark bands were either sharp (Plate 7, fig. 5) (abrupt color change within a millimeter), or gradational (gradual change through growth band width). No external features correlate with these internal bands. Lustig (1971) stated that each growth band in Nevadan chaetetids was formed by 10 to 13 fine growth laminae and that the spacing of these laminae produced light or dark bands (i.e. the closer the spacing of the growth laminae, the lighter the growth band). Laminae within growth bands, differences in crystal size, structure, or calicle wall dimensions were not observed in thin sections or SEM photographs of Kansas specimens (Plate 7, figs. 1 & 2).

Lustig (1971) noted that estimates of growth rate in fossil corals (Table 5) averaged 5 mm per year and on this basis concluded that a growth rate of two millimeters per year was a reasonable growth rate for chaetetids. She stated (p. 55):

> The presence of 10 to 13 growth laminae per growth band is further evidence of a yearly duration of each band, the distance between successive laminae probably representing approximately a lunar month's growth.

Growth rates of sclerosponges have not been accurately determined (Hartman and Goreau, 1972. 1975). An approximation may be obtained by considering accretion rates of the deep fore-reef regions of northern Jamaica where sclerosponges often comprise up to 95 percent of the substrate. Lang, et al.(1975) and Goreau and Land (1974) obtained samples from this area and age dated them using C^{14}. Growth rates calculated from their data ranged from 1.2 to 2.5 mm per year. These rough approximations seem reasonable and within the range of those obtained for corals and the values suggested by Lustig (1971).

Table 5

Growth Rates of Fossil and Recent Corals and Sponges

Organism	Source	Growth Rate (mm/yr)
Chaetetids	Lustig (1971)	1 - 2
Recent Scleractinians	Ma (1937)	5
Acropora	Tamura and Hata (1932)	11.9
Porites	Major (1918)	13
Non-reef building corals	Vaughn and Wells (1943)	5
Devonian Rugose	Ma (1937)	5 - 10
Halysitidae	Hamada (1959) Buehler (1955)	2 - 3
Sclerosponges	Lang, *et al*. (1975) Goreau and Land (1974)	1.2 - 2.5

Skeletal Accretion

If we assume that chaetetids are sclerosponges then we can define "skeletal accretion" as the construction and enlargement of the skeletal components as opposed to the classical reproductive growth of colonial corals discussed by Oliver (1968). Lustig (1971), interpreting chaetetids as corals, described skeletal enlargement by reproduction through axial and coenenchymal increase. She described the morphologic (geometric) changes of the hard parts (skeleton) during calicle division. Although her skeletal descriptions are generally applicably to chaetetids from southeastern Kansas, her interpretations of the soft parts of chaetetids have been superceded by their taxonomic shift from corals to sponges (Hartman and Goreau, 1972).

Skeletal accretion consists of: 1) longitudinal fission (axial increase of Lustig, 1971) and 2) coenenchymal enlargement (coenenchymal increase). Only physical changes in the chaetetid skeleton will be described in order to avoid confusion between the biologic implications of skeletal accretion (enlargement) of sclerosponges and skeletal increase (reproduction) of colonial corals.

Longitudinal Fission.-- Longitudinal fission in chaetetids involves the development of one or two pseudosepta dividing an existing calicle into two equal or subequal "new" calicles (fig. 10; Plate 7, fig. 4). Pseudosepta (Moore and Jeffords, 1945) or neophragma (Lustig, 1971) are incipient walls which arise at right angles from the existing calicle walls. With few exceptions, pseudosepta divide the calicle along its shortest dimension. Calicle division, observed in chaetetids from southeastern Kansas, differs from that described by Lustig (1971) for Atokan chaetetids in the following ways: 1) more than two pseudoseptal ingrowths during calicle division were

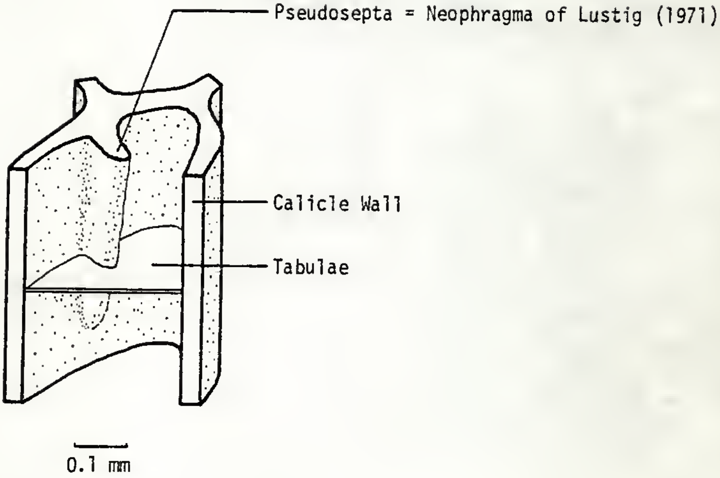


Figure 10. Skeletal Accretion by Longitudinal Fission (modified from Lustig, 1971)

rare (less than 5 percent of those observed) and more than four pseudoseptal ingrowths (one calicle into four) were not observed, 2) resorption of pseudosepta was not observed, 3) tripartition of calicles, either simultaneously or in steps as described by Lustig (1971) was not observed, and 4) calicle accretion (increase) in not considered parricidal because the organic tissue of chaetetids would not be destroyed during calicle division.

Calicles in the process of dividing are larger than other calicles, so it can be assumed that an increase in calicle size occurs during division (Plate 7, fig. 4; Appendix V).

Coenenchymal Enlargement.-- Kirkpatrick (1911, p. 673) described the process of coenenchymal enlargement of Merlia normani; this may be applicable to that of chaetetids. He noted incomplete polygons composed of slender bars at the extreme edges of the sponge tissue and stated:

> In young stages...the slender bars are no more than smears or streaks of flakes, scales, or lumps somewhat higher at points where tubercles will be formed.

These flakes or scales later become ridges by calcocyte secretion of calcite. Polygonal outlines progress to circular pits with tubercles and finally to calicles with tabulae (fig. 11).

At the edges of skeletal development in three chaetetids, slender bars and tubercles similar to those described by Kirkpatrick (1911) were observed (Plate 6, fig. 1). These features are rare and could be easily obscured by erosion, algal or other encrustations, or coated by entombing micrite.

Coenenchymal enlargement in areas where vertical growth by division is dominant, as described by Lustig (1971), was not observed.

A reduction in the number of calicles (calicle decrease) during vertical growth occurs along folds of chaetetids and where calicles merge

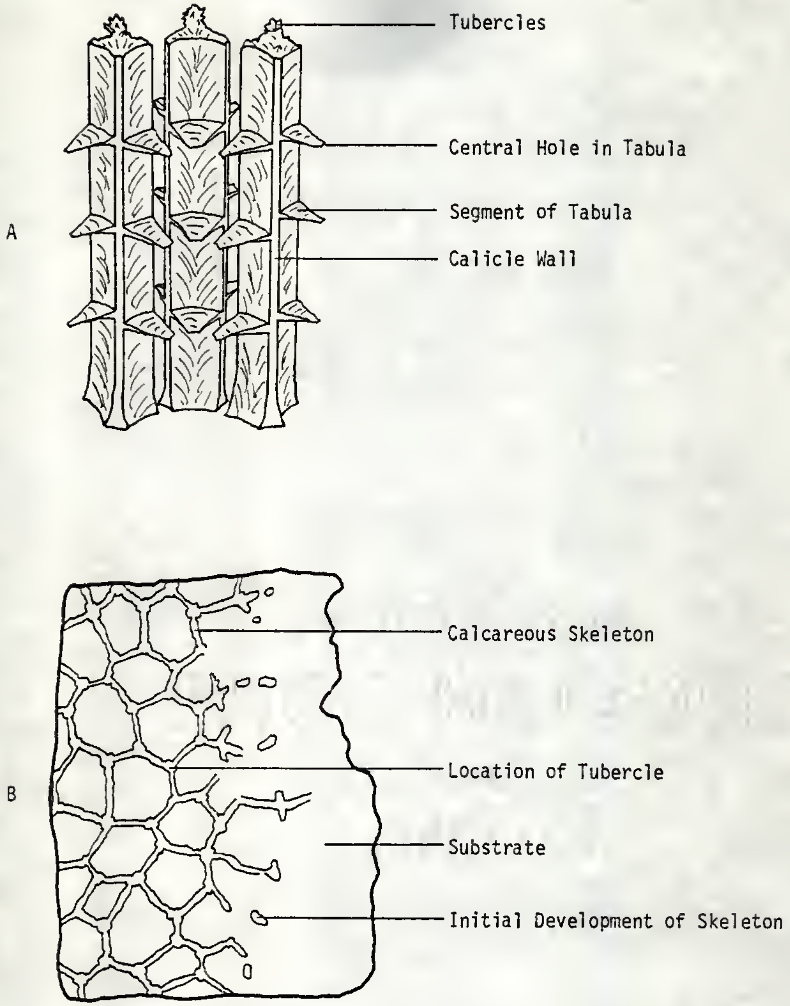


Figure 11. Skeletal Structure of *Merlia normani* (A), and Coenenchymal Enlargement (B) (modified from Kirkpatrick, 1911).

together. Calicle decrease proceeds by an abrupt termination of a calicle wall and decrease in diameter of the two previously separated calicles (Plate 7, fig. 3). Calicle decrease has not been previously reported in chaetetids.

Astrorhizae

Stellate patterns composed of calicles arranged linearly were found on 12 specimens (Plate 6, fig. 4 & 5). Structures of this general form, but differing in detailed relationships to skeletal features, are found in stromatoporoids, hydrozoans and sclerosponges and are called astrorhizae. Hartman and Goreau (1972) mention earlier reports of astrorhizae in chaetetids but doubt their homology with the astrorhizae of living sclerosponges. The structures observed in this study differ from those of Hartman and Goreau (1972) but certainly fit the general pattern of astrorhizae; I will use that term with the understanding that it does not imply the specific details (or function) in living sclerosponges.

Diameters of astrorhizae range from 0.8 to 1.8 cm (Table 6A). Most chaetetids contained less than ten astrorhizae except two specimens (CM1-F45 and CM1-F40) which contained 11 and 40 astrorhizae respectively. Measurements could not be made on all astrorhizae because they often were incompletely exposed because of algae encrustations, matrix-coated or obscured by erosion. One specimen (CM1-F40) contained complete, well-preserved astrorhizae which were believed to be representative of the arrangement and density of astrorhizae during the life of the organism. On this basis, the astrorhizae in a 12.5 cm^2 area were counted and a maximum density of 72 astrorhizae per square decimeter obtained. Twelve measurements of the distance from the center of an astrorhizae to the center of its "nearest

Table 6

Numerical Data of Astrorhizae Dimensions from Amoret Chaetetids

A. Diameter (cm)

CM1-21	CM1-22	CM1-F39	CM1-F40*	CM1-F45
1.4	1.4	1.4	0.8	0.9
0.8	0.9	1.1	1.3	1.2
		0.8	1.3	1.1
		0.8	1.0	1.0
			1.4	0.8
			1.2	0.9
			1.2	1.2
			1.3	1.3
			1.2	0.8
			1.7	0.8
			1.1	0.9
			1.4	
			1.8	
			1.2	
			1.3	
			1.2	
			1.5	
1.10	1.15	1.03	1.29	0.99

*Measurements on the 17 best preserved astrorhizae

B. Spacing

Distance from center of astrorhizae to "nearest heighbor" on specimen CM1-F40 (cm).

1.3, 0.9, 0.8, 1.0, 1.4, 1.3, 0.9, 0.8, 1.4, 1.4, 1.5, 1.5

Average: 1.18 cm

neighbor" were made to obtain an optimum value for the spacing of astrorhizae. Values range from 0.8 to 1.5 cm averaging 1.18 cm (Table 6B).

Hartman and Goreau (1972) stated that inhibition of aragonite deposition along exhalant canals of sclerosponges was responsible for indentation of the skeletal surfaces forming these astrorhizal patterns. They also reported that the absence of astrorhizae on Merlia was due to the smaller diameter of the exhalant canals and the cushioning effect of tissue directly above the calcareous skeleton.

The occurrence of most astrorhizae on the bottom (next to the substrate) of chaetetids can then be explained by the: 1) pressure exerted by the skeleton against the exhalant canals causing greater inhibition of skeletal growth on the underside, and 2) protection of these structures from exposure after death of the organism.

Tubercles

Small conical structures called tubercles (Kirkpatrick, 1911) were observed on surfaces of three chaetetids at the confluence of calicle walls (fig. 11; Plate 6, fig. 1). Kirkpatrick (1911) described tubercles (75 microns high with a basal diameter of 75 microns) on skeletons of Merlia (fig. 11). These structures (in Merlia) are composed of small, sharp-pointed conules which differ in size and shape. Although Kirkpatrick (1911) did not discuss the function of these features, he noted that tubercles were higher in relief than the calicle edges.

Hartman and Goreau (1972) also noted spines protruding around the perimeter of the calicle walls. They believed that these trabecular elements were laid down in advance of the surrounding aragonite but did not speculate on their function.

Chaetetid tubercles project 0.14 mm (maximum) above the calicle surface on some specimens. Unfortunately, these are fine structures which are easily eroded, covered by Osagia or matrix, and only a few were observed.

Symbiotic Features

Two features on chaetetid surfaces suggest possible symbiotic relationships in which other organisms used the chaetetid skeleton as a substrate.

Borings.-- One-hundred-eighteen small ellipsoidal pits were observed on 11 chaetetid specimens. These pits ranged fron 1.5 to 3.3 mm (averaging 2.3 mm) long and ranged from 0.6 to 1.5 mm (averaging 1.1 mm) wide (Table 7; Plate 8, fig. 1).

Rhodda and Fisher (1962) described similar features and showed that they were caused by acrothoracic barnacles. Tasch (1973) also discussed acrothoracic barnacles and stated that in the Paleozoic they bored into shells of molluscs, plates of echinoderms, shells of brachiopods, rugose corals and ectoprocts. Barnacle borings were illustrated by De Vries (1955) on chaetetids in the Amoret Limestone Member of Iowa but he did not identify them as such. Recently Rodriguez and Gutshick (1977) discussed barnacle borings in Devonian fossils of Missouri. They reviewed the literature and suggested that: 1) "blisters" on skeletons were produced in reaction to barnacle borings on live hosts, and 2) borings on the shell interiors, broken shell surfaces, and (or) cardinal area of brachiopod valves indicate a dead host.

Borings in chaetetid surfaces compare favorably to acrothoracic borings described by Rhodda and Fisher (1962) and Tomlinson (1969). No calicle deformation was observed suggesting that the host died prior to boring. On one chaetetid, borings were on one side of the skeleton. On other specimens,

Table 7

Dimensions of Barnacle Borings (mm) on Chaetetid Surfaces from Southeastern Kansas

Specimen *							
CM1-19		CM1-20		CM1-F40		CM1-F45	
W	L	W	L	W	L	W	L
1.1	2.1	1.1	1.7	1.3	2.9	1.3	2.5
1.3	1.8	1.1	2.5	1.1	2.1	0.7	1.9
1.4	2.6	1.5	2.8	1.3	2.4	0.9	1.7
1.5	2.6	1.3	2.5	1.0	2.5	1.0	2.4
		1.1	2.3	0.9	1.8	0.8	2.8
		1.3	2.5	1.0	2.0	0.8	2.5
		1.3	2.4	0.9	2.3	0.9	3.1
		1.3	2.4	1.3	2.9		
		1.0	2.0	1.0	2.0		
		0.9	1.7	1.1	1.9		
		0.8	1.7	1.1	2.1		
		1.2	2.4	0.6	1.6		
		1.3	3.1	1.0	1.9		
		0.8	1.9	1.4	1.9		
		1.4	1.8	0.8	2.0		
		1.0	2.1	0.9	1.9		
		1.2	2.4	1.0	2.3		
		0.9	1.6	0.9	1.7		
		0.8	1.7	1.0	2.0		
		0.9	2.1	1.0	2.1		
		0.8	1.9	1.0	1.9		
		0.7	1.5	1.0	2.0		
		1.3	2.5	1.0	2.1		
		1.2	2.5	0.9	1.7		
		1.1	3.3				
		1.4	2.3				
		0.8	2.0				
		0.8	1.7				
avg. 1.3 X 2.3 mm		1.0 X 2.2 mm		1.0 X 2.1 mm		0.9 X 2.4 mm	

* Measurements on specimens with 4 or more borings

borings were irregularly oriented along the peripheral regions of the skeleton.

In two cores through chaetetids and 18 polished specimens, internal borings were observed (Plate 8, fig. 4). These borings are irregularly shaped and filled with sparry calcite or micrite and range from 0.08 to 0.81 cm in diameter (averaging 0.21 cm) (Table 8). Calicles were not deformed around the holes suggesting that they were post-mortem features or that they occurred below the surface of the living tissue.

De Vries (1955) discussed borings of two different sizes in chaetetids from Iowa and believed that they were a result of boring bivalves.

Two subfamilies of boring bivalves are believed to have lived during the Pennsylvanian; Lithophaginae and Martesiinae (Kauffman, 1969). The shapes of bore holes of some species in these subfamilies are similar to those found in Kansas specimens. Most species are two to five times larger than the borings in chaetetids indicating that: 1) only the juvenile stages bored into chaetetids and the chaetetids continued to grow killing the borers, 2) members of these subfamilies were smaller during the Pennsylvanian, or 3) these borings were due to other organisms. The last of these is believed most likely because: 1) the size and shape of borings are irregular, 2) no skeletons of bivalves have been observed "entombed" in the chaetetid skeleton, and 3) no bivalves have been observed in any associates lithologies.

<u>"Worm Tubes"</u>.-- On the surface of three specimens and on cut and polished surfaces of 13 other chaetetids are holes that deformed the chaetetid skeleton. Arrangement of calicles around these tubes are irregular or meandroid in form. Diameters of the tubes range from 0.05 to 0.52 cm averaging 0.16 cm (Plate 8, figs. 2 & 3) (Table 8).

Table 8

Diameters of Internal Borings and "Worm Tubes" in Chaetetid Skeletons from Southeastern Kansas

Specimen	"Worm Tubes" (cm)	Internal Borings (cm)
CM1-F1	0.21 0.22	0.28
CM1-F4	0.13	
CM1-F9	0.20	0.12
CM1-F11		0.19 0.15
CM1-F18	0.16	0.18
CM1-19	0.20 0.34 0.11 0.08 0.06	
CM1-20	0.06	0.18
CM1-F21		0.81
CM1-22	0.09	
CM1-F24	0.12	
CM1-25		0.35
CM1-F25		0.17 0.08
CM1-F26	0.14	
CM1-F29	0.21 0.19	
CM1-F31	0.10 0.05	
CM1-F37	0.20 0.07	0.28

Table 8

(cont.)

Specimen	"Worm Tubes" (cm)	Internal Borings (cm)
CM1-F39	0.52 0.16 0.12	0.10 0.14 0.12 0.19
CM1-F45	0.10	0.13
CL7-F23	0.20	0.19 0.25 0.28
CL6-B	0.19	0.20 0.18 0.13
Average:	0.16	0.21
Range:	0.05 - 0.52	0.08 - 0.81

Okulitch (1936) described similar features and suggested that they were due to serpulid worms. Kirkpatrick (1911) also described this type of skeletal deformation in Merlia around "the mouth of a worm tube" (p. 673). Skeletal deformation in sclerosponges, as a result of serpulid worms, was observed by Hartman and Goreau (1972). On the basis of close similarities between skeletal deformation in Kansas specimens and reported deformation of sclerosponges and chaetetids, I believe that serpulid worms were responsible for this irregular arrangement of chaetetid calicles.

Erosional and (or) Diagenetic Features

Three features suggest alteration of chaetetid mounds shortly after death: 1) surface cracks, 2) microstylolites, and 3) flattened surfaces.

Surface Cracks.-- Large cracks ranging up to 16 cm long, a centimeter wide, and 1.7 cm deep were observed on 24 specimens (Plate 8, fig. 1). Smaller fractures are observed within the chaetetid skeleton starting at interruption partings (growth discontinuities which will be discussed later) and directed toward the center of the chaetetid. Originally these fractures were believed to be a result of: 1) desiccation, or 2) compaction and pressure of overlying rocks during diagenesis. Micrite fills external fractures and is laminated, with individual laminae concave up (toward the chaetetid surface). Internal fractures are filled with micrite (similar to that in the external fractures) or sparry calcite. If desiccation produced these internal fractures then the chaetetid would have had to be subaerially exposed, filled with micrite, and resubmerged for continued chaetetid growth over the fracture. Desiccation cracks in corals or sclerosponges have not been reported and surfaces of 12 chaetetids with fractures show no evidence of erosion or subaerial exposure. From this evidence the desiccation origin of these fractures is uncertain. Compaction and pressure could produce surface fractures but would not explain internal fractures filled with micrite. The origin of these surface fractures in chaetetids remains enigmatic.

Microstylolites.-- Microstylolites have been observed: 1) in thin sections of chaetetids, 2) transecting large mounds in the field, and 3) in the associated rocks.

Shinn, et al. (1977) produced minor skeletal deformation and microstylolites by compacting unconsolidated carbonate muds from Florida Bay. An early survey of stylolite formation is given by Marsh (1867). Several processes have been suggested for stylolite formation such as compaction-pressure (Shaub, 1953) and soft sediment dissolution (Prokopovitch, 1952) but the trend now favors pressure solution (Wagner, 1913; Stockdale, 1943; Brown, 1959; and Manten, 1966). These theories may explain the microstylolites in chaetetids and reflect the pressure involved in compacting the Amoret Limestone Member.

Flattened Surfaces.-- Flattened and eroded surfaces (Plate 6, fig. 4) were observed on 22 of 50 specimens. Although these features may be explained by recent weathering, similar structures have been observed on corals which were subaerially exposed long enough to erode the top and increase lateral growth (Scatterday, 1977). Winston (1964) reported Chaetetes mounds which had been disoriented and planed off. He believed these features were produced in an environment of by-passing and scour during maximum regression at the top of depositional cycles. Within the framework of the reconstructed environments, chaetetids with planed off surfaces were closer to shore in shallow water. Similar mechanisms may have produced the flattened surfaces on Kansas chaetetids, as the depositional environment appears similar to that described by Winston (1964), but direct evidence is lacking.

Interruption Partings

Interruption partings (Nelson and Langenheim, in press) were observed in all polished surfaces of chaetetids (Plate 7, figs. 3-5) and represent an interruption in vertical growth of the calicle. Lithologically, these partings are composed of sparry calcite or fine-grained micrite and may contain pelloids, foraminifers, worm tubes, *Osagia*, or unidentifiable skeletal grains. Interruption partings are parallel to growth bands and the external form of the chaetetid. These partings may cover the entire surface of the chaetetid or may be locally restricted with as little as five to ten calicles showing discontinuities in growth (Plate 7, fig. 5). Subsequent growth around and above these partings is initiated by another part of the chaetetid which had not been buried. Skeletal growth is continued by coenenchymal enlargement and may continue directly above the distal end of the calicle or be separated by up to 1.5 cm of micrite.

Lustig (1971) described similar features and rejected the possibilities of desiccation and increase in terrigenous sedimentation as causes of these growth discontinuities. She suggested plankton blooms, disturbances which affect algae, predation, and settling of sessile or encrusting organisms as possible mechanisms responsible for interruption partings. Nelson and Langenheim (in press) rejected emergence, erosion, breakage, or environmental changes (*i.e.* temperature, salinity, or food supply) as mechanisms causing interruption partings because these events would affect the entire organism. They suggest periodic, short-lived influx of fine-grained sediment as a more likely interruption mechanism and this may only affect part of the chaetetid. Hartman and Goreau (1975) described a mechanism for interruption partings in tabulate sponges. They stated (p. 3):

> It is characteristic of this sponge to die back at unknown intervals of time, perhaps erratically, and put forth new groups of calicles at a level above the previously living surface. As a result three or more "generations" of dead, flattened masses of skeleton may overlie one another, the topmost alive and often irregular in outline and sometimes subdivided into numerous small "islands" of living tissue.

Interruption partings in chaetetids are believed a result of three mechanisms: 1) sediment coatings, 2) encrusting organisms, and 3) chaetetid death. Nelson and Langenheim's (in press) postulation of periodic, short-lived influxes of fine-grained sediment might produce partial or complete death of the chaetetid with renewed growth covering the micrite coating. Osagia and skeletal fragments on chaetetid surfaces (and in interruption partings) could have caused areally restricted growth discontinuities. "Islands" of living tissue (in the form of skeletal patches) are observed on two specimens which are believed similar to those described by Hartman and Goreau (1975).

Spicules

Spicules were infrequently observed in the chaetetid skeletons, but were much more common in the matrix. Five spicules, averaging 0.033 mm in diameter and ranging from 0.028 to 0.043 mm, were observed in one chaetetid (Plate 4, figs. 2 & 3). The spicules are smooth styles with ends embedded in the calicle walls so length measurements could not be made. SEM examination of calicle walls showed small holes (Plate 4, fig. 5) which may have been formed by the dissolution of the original spicules.

Hartman and Goreau (1972) found opaline spicules in sclerosponges that had been eroded after entrapment in the aragonitic skeleton and before death of the organism. Land (1976) in studying sclerosponge spicules from North Jamaica, observed early dissolution of acanthostyles, "a few centimeters beneath the living tissue..." (p. 967). He noted enlarged central canals, eroded spines and holes drilled in spicules from the outside and suggested biological processes were largely responsible for the dissolution.

Additionally, Hartman and Goreau (1970a, 1970b) reported areas in the skeleton of Ceratoporella nicholsoni to be void of spicules and Kirkpatrick (1911) found no spicules enclosed in the skeleton of Merlia. Acanthochaetetes possesses spicules in the outer third of the intra-calicle tissue but they are not incorporated into the skeleton. In comparing Acanthochaetetes with Favosites Hartman and Goreau (1975, p. 10) stated that:

> Studies of both Merlia and Acanthochaetetes indicate that the absence of siliceous spicules (or their pseudomorphs) embedded in the calcareous skeleton does not gainsay poriferan affinities for fossils with otherwise suggestive characteristics.

Only one case of possible spicular entrapment has been reported in chaetetids (Schnorf-Steiner, 1963) and these were randomly arranged calcareous pseudomorphs in the calicle interiors. Friedman, et al. (1974, 1976) reported a recent example of the dissolution of silica and concurrent precipitation of calcium carbonate producing pseudomorphs of the original quartz particles.

In several cases, siliceous spicules or calcareous pseudomorphs of siliceous spicules have been reported in units associated with chaetetid build-ups (Moore and Jeffords, 1945; Lustig, 1971; Spaw, 1977; Mathewson, 1977). Spicules in thin sections of intermound lithologies (Plate 4, fig. 4) were from two to 40 times larger than the dimensions of spicules in extant sclerosponges. These larger spicules could be: 1) due to changes in size during the process producing the pseudomorphs, 2) produced by other sponges, or 3) produced by chaetetids possessing larger spicules than extant sclerosponges.

Substrates

As previously mentioned, all chaetetids initially encrust or coat some object. Substrates on which initial chaetetid growth occurs are: 1) biotic fragments, 2) lithologic fragments, or 3) features which are represented in the rock as organic rich, argillaceous partings.

Organic partings consist of thin bands of black organic carbon with fine skeletal fragments interspersed throughout. Only one of the fifty collected specimens grew on an organic parting.

Lithologic fragments consist of fine-grained calcite probably originating from the surrounding sediment at the time of deposition. Twelve specimens used a combination of lithologic fragments and oncolites as a substrate. In two other specimens the lithologic fragments were a silty shale (probably the Bandera Shale, which underlies the Amoret Limestone Member).

Biotic fragments are the substrate for 41 specimens. Oncolites are included in this category as a matter of convience and constitute the substrate for 34 chaetetids. Eight chaetetids encrust the upper surfaces of skeletal fragments such as productaceans or spiriferaceans.

Thirty-seven chaetetids encrust more than one of these categories and at least one oncolite was included in each multiple substrate. Oncolites are the dominant substrate, presumably because they were the most abundant structure offering a firm, stable attachment surface.

Chaetetid Development

Dimensions of collected chaetetids range from 1.8 cm to approximately 26 cm in diameter. Polished surfaces helped to define a hypothetical sequence in the development of chaetetid shingles, columns, and mounds (fig. 9).

Lustig (1971) was unable to determine the initial stage in chaetetid development, but believed that initiation of growth would be represented by a protocorallite.

Hartman (1969) observed egg cells in the sclerosponge Stromatospongia vermicola and believed that this species incubates its larvae. The sexual or asexual (gemmules) processes of other sclerosponges have not been reported.

To discuss chaetetid development, it is assumed that Hartman and Goreau are correct in interpreting chaetetids as sclerosponges and indeed the features I have observed in Amoret chaetetids support this assumption. A gemmule or larva settles and attaches to a relatively solid substrate such as a shell fragment, oncolite, or another chaetetid skeleton. Substrate preference may be given to objects which are more stable such as dead chaetetid skeletons or oncolites. This would keep initial stages away from the sediment-water interface and reduce the hazards of burial or abrasion.

Initial development includes the expansion of the living tissue and deposition of a basal epitheca which conforms closely to the topography of the substrate. As this basal epitheca develops, calicles are laid down as described by Kirkpatrick (1911) through coenenchymal enlargement. From this stage, calicle development may progress in two ways depending on the size and shape of the substrate.

If the substrate is solid (and unlikely to be moved by wave or current action) vertical growth will progress more rapidly than lateral growth. Mound or columnar forms are produced and continue until predation or sediment influx causes the death of all or part of the organism and thus interruption partings.

On the other hand, if the nucleus is rolled by wave or current action, lateral growth will take precedence over vertical growth. The advantage of lateral growth at this stage would be to "coat" the entire surface of the nucleus with sponge tissue and skeletal elements. If the sponge tissue is rolled into the sediment after the coating of the nucleus is completed, it is able to contract the ostia which would exclude sediment from entering the tissue and obstruct fluid passageways. Water may enter the sponge through ostia above the sediment-water interface and provide nutrients to tissue below by means of the interconnected incurrent and excurrent canals. This "coating" process continues until the nucleus becomes stable and vertical growth will then take precedence over lateral growth.

Two variations of this process have been observed. Large chaetetids up to 11 cm high are seen to have been tilted or overturned. Tissue migration to the upper surface has occurred and the organism remained viable (fig. 9, no. 6, p. 36).

The other variation occurs when sediment (substrate) plasticity is such that vertical growth would not be stable even though many oncolites and skeletal fragments are available. In this case, chaetetid growth would continue laterally (after coating a nucleus) and incorporate more nuclei into the basal structure. This would give rise to the shingle growth form (fig. 9, no. 3, p. 36).

Final stages in chaetetid development would be the continued growth of the chaetetid in a vertical direction. An optimum proportion is reached in which vertical growth exceeds lateral growth. At this point the living tissue of the chaetetid covers only the uppermost surface of the chaetetid skeleton, particularly in the columnar forms, and growth on the undersides cease.

Species Determination

Chaetetids in southeastern Kansas share features in common with three species of Chaetetes described by Moore and Jeffords (1945) from the Pennsylvanian of Texas. Moore and Jeffords (1945) did not believe that these three species were conspecific with those in Kansas because of: 1) the more numerous and finer tabulae in C. eximus; 2) the thicker walls, more irregular calicle shape and difference in form of C. favosus; and 3) the smaller calicle diameter of C. subtilis. Chaetetids from Kansas have closer spacing of tabulae, smaller calicles and lack the macula-like arrangement of calicles observed in C. schucherti of Oklahoma (Moore and Jeffords, 1945).

Kansas chaetetids are unique among previously described species because they possess: 1) astrorhizae, 2) spicules, 3) a variety of growth forms, 4) a wider range in calicle dimensions (i.e. tabulae thickness, tabulae spacing, calicle diameter, and wall thickness).

I feel that establishment of a new species in not warrented because necessary detailed studies are inadequate in previously reported chaetetids and extant sclerosponges.

As a basis for future comparisons, a description of chaetetids from the Amoret Limestone Member of the Altamont Limestone Formation of southeastern Kansas follows: Basal skeletons are encrusting which produce: 1) shingle forms, 2) mounds up to 70 cm in diameter, or 3) columns up to 1.2

meters in vertical dimension. Calicles are contiguous, polygonal, circular, irregular, and may break down to meandroid. Calicle lengths range from 0.11 to 0.57 mm, averaging 0.33 mm, and widths range from 0.08 to 0.43 mm averaging 0.23 mm. Calicle walls are amalgamated, smooth or irregular and crystal structure of the walls is fibroradial. Thickness of calicle walls range from 0.03 to 0.16 mm and average 0.07 mm. Tabulae are complete or incomplete, concave, convex or flat and range from 0.007 to 0.051 mm, averaging 0.021 mm thick. Spacing of tabulae ranges from 0.495 to 0.082 mm and averages 0.234 mm. Growth bands are common. Astrorhizae are present on the surface but rare in the skeletal interiors and range from 0.8 to 1.8 cm in diameter with a density as high as 72 astrorhizae per square decimeter. Tubercles occur on the skeletal surface at the intersections of calicle walls. Spicules are rare in the calicle lumina and range from 0.028 to 0.043 mm, averaging 0.033 mm, in diameter.

Previous Comparisons

<u>Ceratoporella nicholsoni</u> (a recent sclerosponge) and chaetetids share the following characteristics (Hartman and Goreau, 1972): 1) asexual longitudinal fission of calicles predominantly by two pseudoseptal ingrowths from walls of calicles in <u>Ceratoporella</u> or one pseudoseptal ingrowth in the chaetetids; 2) a common wall between the calicles with a center of calcification along the medial plane; 3) overlapping ranges of calicle diameters; and 4) a tendency for the calicles to break down their regular arrangement when overgrown by other organisms in favor of a meandroid form (Smyth, 1925; Hartman and Goreau, 1972). Additional shared characteristics, although not unique between these groups, are the fibroradial (trabecular) microstructure of the calcareous skeleton, and growth banding.

Hartmen and Goreau (1972) noted major inconsistancies in: 1) the scarcity of reported spicules in the skeleton of chaetetids (Schnorf-Steiner, 1963), 2) the absence of tabulae in Ceratoporella, 3) the lack of reported astrorhizae on chaetetids with the exception of two cases (Bachmayer and Flugel, 1961; Yavorsky, 1947), and 4) the lack of reported symbiotic associations with chaetetids.

Present Comparison

General Morphology and Distribution.-- Hartman and Goreau (1970a) found Ceratoporella to be the largest of the Jamaican sclerosponges ranging up to one meter in diameter and 50 centimeters thick. Ceratoporella is usually dome-shaped and resembles botryoidal malachite (Hartman and Goreau, 1972) with rounded mamelons. Young ceratoporellids may be pedunculate whereas older individuals form a series of dome-shaped masses on top of each other. Other sclerosponges (Stromatospongia vermicola, Hispedopetra, and Merlia) may be encrusting and securely cemented to a substrate of shells, coral branches, foraminifers, worm tubes or other sclerosponge skeletons.

Lang, et al.(1975) discussed spatial distribution of individual sclerosponges. At depths between 74 and 98 m, C. nicholsoni composes between 25 and 50 percent of the living cover. No living sclerosponges were found in contact, but their skeletons often provided a substrate for growth of the same or other sclerosponge genera.

Chaetetids and sclerosponges are similar in general morphology, size and spatial distribution (Table 9). Dissimilarities occur in the absence of pedunculate individuals (i.e. not observed in chaetetids) and rounded bosses on sclerosponge surfaces. All chaetetids in southeastern Kansas

Table 9

Comparison of the General Morphology, Size and Spatial Distribution of Chaetetids with Sclerosponges

Characteristic	*Chaetetes*	*Ceratoporella****	*Merlia***	*Acanthochaetetes**
Morphology	Shingles Mounds Columns	Lamellar Mounds	Lamellar Small Encrustations	Lamellar up to 33 cm dia.
Astrorhizae	Present	Present	Absent	Present
Tubercles	Present	Present	Present	Present
Growth Bands	Present	Present	Present	Present
Skeletal Enlargement	Longitudinal Fission Coenenchymal Enlarg.	Long. Fission	Long. Fission	Intramural Offsets
Skeletal Mineralogy Microstructure	Aragonitic(?) Fibroradial	Aragonitic Fibroradial	Aragonitic Fibroradial	Calcitic Granular
Spatial Distribution	Patchy-Sparse to Crowded	Patchy-Sparse to Crowded	Patchy-Sparse	Patchy-Sparse
Ecology	Non-cryptic	Cryptic or Non-cryptic	Cryptic or Non-cryptic	Cryptic or Non-cryptic
Symbiotic Relationships	Present	Present	Present	No Data

* Hartman and Goreau (1975), ** Kirkpatrick (1911), *** Hartman and Goreau (1972)

were encrusting but non-encrusting individuals of sclerosponges have been observed off the coast of Jamaica.

Skeletal Macrostructure.-- Skeletal surfaces of sclerosponges are marked by closely spaced circular, elliptical or irregularly shaped calicles but only one dimension has been reported. Oiameters range from 0.2 to 0.5 mm in *C. nicholsoni* and from 0.18 to 0.22 mm in *Merlia*. Calicle structure shows no evidence of dimorphism in sclerosponges. Hartman and Goreau (1970a) reported that calicles maintained the same diameter, but a channel, often present in the aragonitic-filled lumina, tapers proximally. *Ceratoporella* and *Merlia* possess irregular spine-like processes (tubercles) at the calicle edges. An epitheca is present in young individuals, but may be obscured as growth continues. Calicle walls are smooth with no mural pores and range in thickness from 0.036 to 0.042 mm in *C. nicholsoni* and from 0.04 to 0.06 mm in *Merlia*.

Skeletal enlargement is by longitudinal fission of calicles through single or double pseudoseptal growth. Tabulae are not observed in *C. nicholsoni* and calicles are filled with aragonite to within one to 1.2 mm of the skeletal surface. This provides a base for the living tissue in place of tabulae. On the other hand, *Merlia* and *Acanthochaetetes* are both tabulate sclerosponges. Tabulae are approximately 0.016 mm thick and may be regularly or irregularly spaced at intervals averaging 0.15 mm in *Merlia*. In *Acanthochaetetes*, tabulae range from 0.02 to 0.135 mm thick and are irregularly spaced at 0.05 to 0.5 mm intervals.

In comparison, skeletal macrostructure of chaetetids and sclerosponges show close similarities (Table 10). Calicle diameters in chaetetids are within the range of those in sclerosponges and both possess tubercles of similar size and shape.

Table 10

Comparison of Skeletal Microstructure of Chaetetids with Sclerosponges

Characteristic	Chaetetes	Ceratoporella***	Merlia**	Acanthochaetetes*
Calicle Shape Before Overgrowth	Polygonal to Irregular	Polygonal to Elliptical	Polygonal to Elliptical	Pentagonal Hexagonal Elliptical
Calicle Shape After Overgrowth	Irregular to Meandroid	Irregular to Meandroid	Irregular to Meandroid	No Data
Range of Calicle Dimensions (mm)	L. 0.107-0.569 W. 0.082-0.423	0.2 - 0.5	0.12 - 0.22	L. 0.315-0.615 W. 0.300-0.395
Calicle Walls	Amalgamated	Amalgamated	Amalgamated	Amalgamated
Wall Thickness (mm)	0.031-0.159	0.036-0.042	0.04-0.06	0.065-0.140
Tabulae	Concave, Complete, Horizontal, Convex, Incomplete	-	Horizontal, Complete or Incomplete	Concave, Convex, Horizontal, Complete
Tabulae Thickness (mm)	0.007-0.051	-	0.015	0.02-0.135
Tabulae Spacing (mm)	0.082-0.495	-	0.075-0.25	0.05-0.50
Spicule Diameter (mm) in Skeleton in Tissue	Rare 0.028-0.043 ?	Present 0.0031-0.004	Absent 0.0018-0.003	Absent 0.0026-0.0039

* Data from Hartman and Goreau (1975), ** Kirkpatrick (1911), *** Hartman and Goreau (1972)

Skeletal accretion is by longitudinal fission and coenenchymal enlargement. Calicle walls were slightly larger in chaetetids. Lustig (1971) believed that one of the major differences between chaetetids and sclerosponges was the increase in calicle diameter in chaetetids. Possible explanations for this increase in diameter are: 1) effects of recrystallization, 2) shape of calicles, and 3) replacement of calicle walls. On the other hand, the possibility exists that sclerosponge calicles do increase in diameter.

Hartman and Goreau (1970a) reported that calicle dimensions at the surface were the same as those at the base yet calicle division is by longitudinal fission. If a calicle maintains the same dimension at the base and top, yet divides in the middle, it would be necessary for the calicle to increase in diameter at some stage during division.

Hartman and Goreau (1972) mentioned that calicles are progressively filled by aragonite but leave a channel (averaging 25 microns in diameter) down the center. In this case, the space within the calicle increases toward the distal end but the calicle itself may remain the same diameter.

Wall Microstructure.-- The walls of *Ceratoporella* are composed of trabecular aragonite. Tabulate sclerosponges (*Acanthochaetetes*) possess a calcitic skeleton made up of irregularly arranged needle-like crystalline units.

In thin sections of chaetetids, wall structure is fibroradial but SEM photographs showed that walls consist of discrete calcite grains possibly due to recrystallization or etching.

Spicules.-- Spicules of *C. nicholsoni* are in the form of siliceous acanthostyles ornamented with whorls of spines. Dimensions range from 64 to 394 microns long and 3.1 to 4.0 microns in diameter. Other sclerosponges have spicules in the form of acanthostyles or styles with lengths ranging from 35 to 818 microns and diameters from 1.3 to 2.0 microns: clavidiscs with lengths from 28 to 44 microns and widths of 24 to 28 microns; and long raphids, trichodragmata, slender sigmata, and spirasters (Kirkpatrick, 1911; Hartman and Goreau, 1972, 1975). These spicules may be trapped in the aragonitic or calcitic skeleton.

Only five spicules have been found in chaetetid calicles and they are larger than those of sclerosponges (Table 10). Calcareous pseudomorphs of siliceous spicules occur in thin sections of chaetetid-bearing rocks. Diameters of these pseudomorphs ranged from 18.4 to 82 microns with lengths ranging to 117 microns.

Land (1976) and Hartman and Goreau (1972) have reported the selective removal of opaline silica by biological activity or corrosion from undersaturated sea water and that this could occur prior to the death of the sclerosponge. Additionally, Hartman and Goreau (1972, 1975) have reported that: 1) Merlia and Acanthochaetetes do not contain spicules trapped in the skeleton, and 2) parts of Ceratoporella may be void of spicules.

In comparison, the lack of spicules within calcareous skeletons of chaetetids may be explained by: 1) corrosion or biodegradation before or after death of the organism, or 2) the fact that chaetetids did not trap spicules in skeletal walls.

Astrorhizae.-- Excurrent canals in sclerosponges are often marked by a fine stellate pattern or depression in the aragonitic skeleton. These structures, astrorhizae, are recognized in sclerosponges, stromatoporoids, hydrozoans and chaetetids and have been the topic of considerable discussion (Dehorne, 1920; Steiner, 1932; Jordon, 1969; Hartman and Goreau, 1970a, 1972, 1975; and Stearn, 1972, 1975). To date, few detailed descriptions and measurements of sclerosponge astrorhizae have been reported. Hartman and Goreau (1975) reported diameters of the excurrent system (not the astrorhizae pattern in the skeleton) to range from 1.8 to 4.0 cm.

The astrorhizal depressions in chaetetids I have studied are similar to those found on sclerosponges. Because dimensions have not been reported in sclerosponges, comparison of size and shape cannot be made.

Banding.-- The light and dark growth banding in both the organic tissue and the aragonitic skeleton has been reported in the sclerosponges Ceratoporella nicholsoni and Stromatospongia norea (Hartman and Goreau, 1970a). Although Hartman and Goreau did not discuss their origin, other authors have speculated on the origin of growth bands in both fossil and extant organisms. Some more recent explanations for growth banding have been: 1) influences of the moon on breeding cycles (Korring, 1947; Thorson, 1950; Wells, 1963; Scrutton, 1964; Yonge, 1969), 2) temperature (Ma, 1937), 3) variations in nutrient supply (Wells, 1963), and 4) tides (Termier and Termier, 1975).

Sclerosponges and chaetetids show alternating light and dark growth bands but growth rates have not been accurately determined for either organism. From studies by Lustig (1971), the rate of growth is within the range of the approximations for sclerosponges.

Ecology.-- Sclerosponges are considered part of the cryptofauna of the Jamaica reef. They occur in the twilight zone of caves and submarine tunnels from depths of less than 8 m to greater than 95 m. At greater depths they occur in the open on steep slopes where little sediment accumulates. Ceratoporellids appear to attain maximum size and density at water depths of less than 30 m in caves and tunnels. Associated with

Jamaican sclerosponges are encrusting foraminifers, lithistid sponges, ellisellid Gorgonacea, ectoprocts, thecidioid brachiopods, flabellid corals and serpulid worms. Hartman and Goreau (1970a) were impressed with the close relationship of serpulid worms and sclerosponges which they felt was obligatory in _Stromatospongia vermicola_. Kirkpatrick (1911) also discussed skeletal deformation as a result of lesions caused by worm tubes.

Hartman and Goreau (1970a) were concerned with the lack of reported incidences of symbiotic (commensal or parasitic) associations with chaetetids. The chaetetids collected from southeastern Kansas possess several features which would indicate these relationships did exist. Acrothoracic barnacles, algal encrustations, worm tubes, and features produced by other boring organisms indicate that symbiotic relationships not only existed but were commong among chaetetids.

The major inconsistency between sclerosponges and chaetetids is ecological. Their preferred general ecological niches are different and chaetetids show no parallel to sclerosponges in physical requirements. Interpretations of the depositional environment for the Amoret chaetetids indicate a relatively shallow, normal marine, moderate energy environment well within the photic zone, but sclerosponges prefer cryptic habitats in tropical reefs. Although sclerosponges in shallow waters are confined to caves and submarine tunnels, they reach their maximum size and density in waters less than 30 m deep; these are water depths similar to those postulated for chaetetids.

SUMMARY

In southeastern Kansas, the Amoret Limestone Member of the Altamont Limestone Formation represents a low, intertidal to shallow marine sequence of normal salinities and moderate wave and (or) current energies. The lithologic sequence represents four facies: 1) transition, 2) chaetetid-algal, 3) burrowed-dolomite, and 4) oncolite-brachiopod. Migration of these facies through time and space may have been a result of sea level fluctuation and (or) the influence of a laterally shifting delta originating from the Ozark Uplift.

Chaetetes, an extinct sclerosponge, was the dominant organism in this area during Amoret time forming shingles, mounds, or columns. These organisms, which had been considered tabulate corals, show an even closer relationship to the sclerosponges than had been previously postulated by Hartman and Goreau (1972, 1975).

Chaetetid characteristics common to sclerosponges are: 1) general morphology and spatial distribution, 2) size, shape, and arrangement of calicles, 3) tubercles, 4) growth banding, 5) calicle wall morphology, 6) skeletal accretion, 7) wall microstructure, 8) spicules, 9) symbiotic associations and related skeletal deformation, and 10) astrorhizae.

The major inconsistency between sclerosponges and chaetetids is the non-cryptic habitat of chaetetids. Desmoinesian chaetetids seem to have inhabited moderately shallow marine waters whereas living sclerosponges are confined to the deep fore-reef regions of the Caribbean, Coral Sea or South Pacific or in caves and tunnels at shallower depths. Despite this inconsistency, the systematic position of chaetetids as sclerosponges appears more firmly established.

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APPENDIX I

Measured Sections and Cores

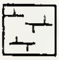
Measured sections and samples were labeled according to the following procedure: *e. g.* CL7-3

C - *Chaetetes*
L - Labette County
7 - Locality number (a small letter after the number indicates an offset from the main section at this locality)
3 - Sample Number

Cores and core samples were labeled as follows: CM1-A

C - *Chaetetes*
M - Montgomery-Labette County Line
1 - Locality Number
A - Sample A from the core

Color designations were those of Goddard *et al.* (1963)
Symbols used in graphic sections are:


massive limestone


phosphatic nodular shale


oncolitic shale


silty shale


chaetetids


massive dolomitized limestone


burrows or borings
algae

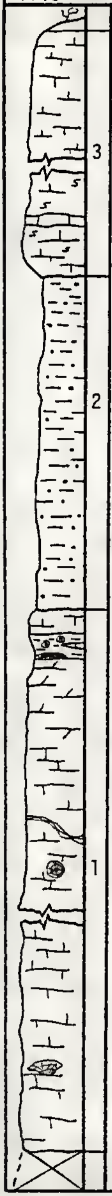

organic partings
microstylolites


chert nodules or lenses
covered interval


interval not drawn in graphic section

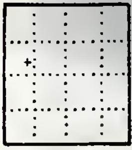
Scale 1:10 No. Sample No. Sec.35 T.34 S. R.17E County Labette Date 6/1/76

Locality Description: SE¼, SW¼, NW¼
Elevation of Base: 222.01 m (728.1')
Locality Number: CM1b
Measured by: James E. Mathewson
Remarks: Active quarry located in same quarry as CM1, 125 m N5E of CM1.

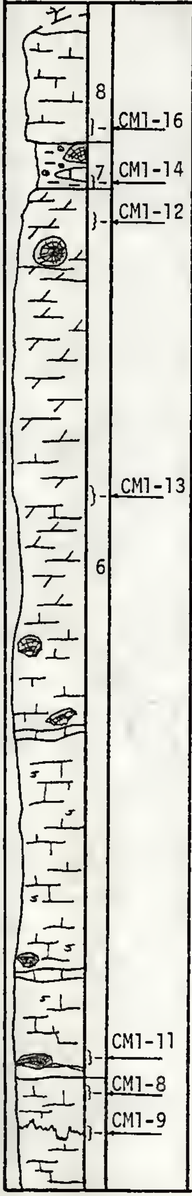


No.	Description	Thickness (cm)
3	Composita, crinoid, phylloid algae, fusulinid, echinoid, Chaetetes bearing biomicrite, light gray (N7) weathers to grayish orange (10YR7/4), thin bedded (6-35 cm), highly fossiliferous, recrystallized, iron nodules scattered thru-out, prominent ledge-former, laminae indistinct, wavy bedding, sharp contact with shale below. (Worland Ls. Mbr.)............................	171
2	Shale, black (N1), fissle, weathers medium gray (N6), abundant phosphatic nodules, black calcareous partings in lower 25 cm, fossils are sparse but trace fossils and plant debris present, nodules often contain Orbiculoidea, thinly laminated, sharp contact with units above and below becoming more calcareous upward. (Lake Neosho Sh. Mbr.)........................	64
1	Chaetetes, algae, brachiopod, crinoid bearing biomicrite, oncolitic shale 23 cm below the top, recrystallized, ferruginous, Composita, Kozlowskia, abundant in upper part of this unit, shale parting at top undulatory usually 9 cm or less thick, upper contact sharp, organic seams and microstylolites interspersed throughout, some cherty lenses and nodules in lower part, light gray (N7), weathers grayish orange (10YR7/4), lower contact unobserved. (Amoret Ls. Mbr.)..............................	173
	Total Thickness.................	408
	Total Thickness of Amoret Ls. Mbr........	173

Scale 1:10 No. Sample No. Sec. 35 T. 34 S. R. 17 E. County Labette Date 6/1/76



Locality Description: SE¼, SW¼, NW¼,
Elevation of Base: 219.6 m (720.0')
Locality Number: CM1
Measured by: James E. Mathewson
Remarks: Active quarry in southwestern Labette County

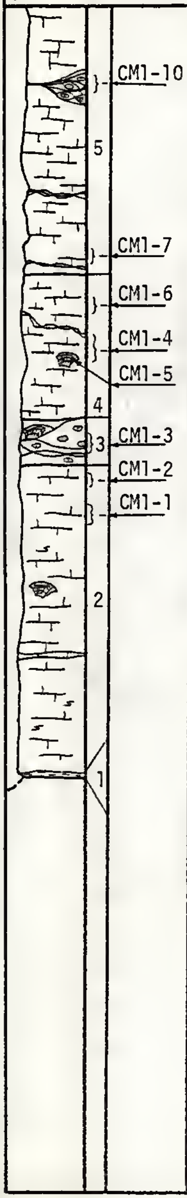


No.	Description	Thickness (cm)
8	Brachiopod, <u>Neospirifer</u>, <u>Composita</u>, <u>Kozlowskia</u>, phylloid algae, crinoid, echinoid, <u>Osagia</u>, bearing biomicrite, thinly bedded, sharp contact with shale below, laminae indistinct, fair outcrop, light gray (N7), weathers grayish orange (10NY7/4), iron stained, abundant large fossils, in some areas large <u>Chaetetes</u> mounds developed and this interval is distorted over the top, abundant finely comminuted skeletal debris...........................	21
7	Shale, calcareous, black (N1), weathers medium dark gray (N4), fissle, thinly laminated, laminae overlie and underlie <u>Osagia</u> oncolites and fossils, thickness variable (1-15 cm), abundant fossils and <u>Chaetetes</u>, upper and lower contact sharp but undulates and is irregular, chaetetids in shingles and columns, calcareous lenses irregularly interspersed in this interval, sample CM1-14 composite sample, CM1-15 random sample from 30 m east of measured section..................................	9
6	Phylloid algae, crinoid, fusulinid, brachiopod, ectoproct bearing biomicrite, recrystallized, finely comminuted skeletal debris, massive, indistinct bedding, pale yellowish brown (10 YR6/2) weathers dark yellowish brown (10YR4/2), mudcracks, borings and burrows throughout upper part, distinct undulating contact below, dolomitic, chert nodules near upper contact, brecciated appearance at contact above, chaetetids in large mounds (up to 60 cm) but sparse, sample CM1-11 base of interval, CM1-12 at top of interval, CM1-13 is 111 cm above base..	171
5	<u>Chaetetes</u>, fusulinid, horn coral, phylloid algae, crinoid, echinoid, gastropod bearing biomicrite, finely crystalline, indistinct bedding, no microstructural features, the base and top of this interval is separated by thin laminae of black (N1) organic debris less than 1 mm thick, from 30-39 cm above base of this interval is a	

Scale 1:10	No.	Sample No.	Sec.	T.	S.	R.	County	Date

Locality Description:

Locality Number: CM1
Measured by:
Remarks: Page 2 of 3



No.	Description	Thickness (cm)
	layer of black (N1) organic debris containing abundant fossils (crinoids, fusulinids, echinoids) and pebble to cobble size nodules covered with chaetetids or Osagia (oncolites), this zone persists laterally 2.58 m and ranges in thickness from 0 to 28 cm. Most of the organic laminae in this interval and the one below occur in this manner (i.e. often dividing and forming pebble-chaetetid zones). These seams often show microstylolites. Color is pale yellowish brown (10YR6/2) and weathers to a dusky yellow brown (10YR2/2). Samples CM1-7, 6 cm above base, CM1-8 at top of interval, CM1-9 stylolite from this interval, CM1-10 chaetetids and nodules from 15 to 25 m S75E of this section..................................	70
4	Chaetetes, brachiopod, algae, horn coral, gastropod bearing biomicrudite or biolithite, pale yellow brown (10YR6/2), indistinct bedding but allochems subparallel to bedding, chaetetids present as mounds (20 X 14 cm) rare but usually as lenses (7 X 20 cm), several thin (1 mm or less) black (N1) organic seams persist throuout this interval and are undulatory containing fusulinids, crinoids, horn corals and chaetetids. Chaetetes seem to initiate on these seams. This interval is laterally persistant but varies in thickness, samples CM1-4a and b from 10 and 19 cm above base, CM1-6, 11 cm below top of this interval................	28
3	Chaetetes, fusulinid, crinoid bearing biomicrudite, laterally persistant, undulatory seams 3-9 cm thick, moderate brown (5YR3/4) with thin (4 mm or less) black (N1) carbonaceous laminae, chaetetids in this seam but more often as shingles or mounds immediately above, fusulinid zone distorted beneath chaetetids. chert nodules occur in this interval, sharp contact above, samples CM1-3 and CM1-2 from this interval ....:..............................	9
2	Brachiopod, foraminifer, phylloid algae, Osagia	

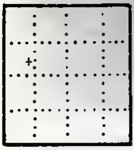
Scale 1:10 No. Sample No. Sec. T. S. R. County Date

Locality Description:

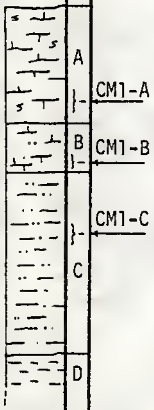
Locality Number: CM1
Measured by:
Remarks: Page 3 of 3

No.	Description	Thickness (cm)
	crinoid bearing biomicrite, finely crystalline olive black (5Y2/1), weathers very light gray (N7), bedding indistinct but allochems subparallel to inferred bedding, no visible structures, no chaetetids, sharp contact with unit below, undulating irregular contact with fusulinid zone above, samples taken 40-48 cm above base of this interval CM1-1.............	60
1	Organic seam with some skeletal debris..........	.4
	OFFSET 24 m N5E OF THIS SECTION AT SAME ELEVATION FOR CORE	
	Total Thickness of Amoret Ls. Mbr...	368.4

Scale 1:10 No. Sample No. Sec. 35 T. 34 S. R. 17 E County Labette Date 4/5/77

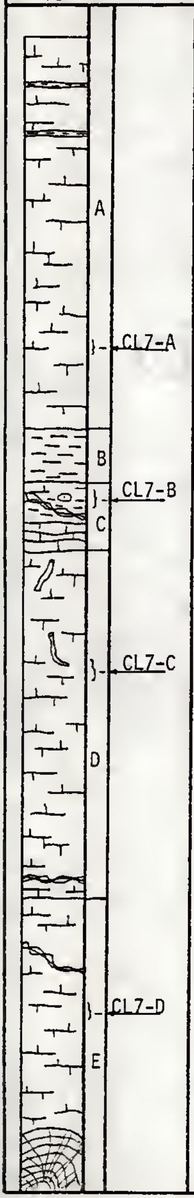


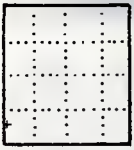
Locality Description: SE¼, SW¼, NW¼,
Elevation on top of core: 219.6 m (720')
Locality Number: CM1core
Measured by: James E. Mathewson
Remarks: Top of core at same elevation as CM1 and 25 m N5E.



No.	Description	Thickness (cm)
A	*Ivanovia*, fusulinid, ostracode, intraclast, biserial and uniserial foraminifer, coated grain (*Osagia*), crinoid, gastropod, pelloid, horn coral bearing biomicrite, recrystallized, medium light gray (N6), skeletal debris finely communited, calcareous intraclasts ranging up to 1 cm thick, few fossils, bedding or laminae indistinct, sharp contact with unit below......	22
B	Brachiopod, phylloid algae, quartz silt, pyrite bearing biomicrite, skeletal debris finely comminuted and difficult to identify but comprising 60 percent of the rock volume, medium gray (N5) with medium dark gray (N4) to dark gray (N3) carbonaceous seams, more silty toward base, pyrite abundant, laminae indistinct, less calcareous toward base, sharp contact with interval below................................	10
C	Calcareous, micaceous siltstone, medium gray (N5) with medium dark gray (N4) to dark gray (N3) stringers 4 mm or less in thickness subparallel to inferred bedding, laminae seem bioturbated and bored with dark gray (N3) infilling of bores or burrows which are up to 8 mm along long axis and 4 mm along narrow axis, calcareous clasts through out this interval......	35
D	Mudstone, light gray (N6), unable to obtain consolidated sample with coring device...........	.5
	Total Thickness............................	67.6
	Total Thickness of Amoret Ls. Mbr.........	32

Scale 1:10 No. Sample No. Sec. 11 T. 35 S. R. 18 E County Labette Date 5/27/77

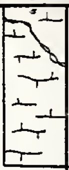




Locality Description: SW¼, SW¼, SW¼
Elevation at top of core: 267.41 m (877.3')
Locality Number: CL7core
Measured by: James E. Mathewson
Remarks: Core taken along road cut 50 m south of measured section.

No.	Description	Thickness (cm)
A	Crinoid, foraminifer, worm tube, ostracode, productacean, Osagia, pelloid, phylloid algae, sphere, gastropod bearing biomicrite and biosparite, iron stained, bored, thin shale(?) breaks or ferruginous interval at 8 and 13 cm from top of first 18.7 cm core, in third section of core was a 8.5 cm ferruginous interval, color grayish orange pink (5YR7/2) to pale yellowish brown (10YR6/2), ferruginous interval was dark yellowish orange (10YT6/6), sharp contact with unit below. (Worland Ls. Mbr.)	75
B	Calcareous, ferruginous shale, few fossils, Composita, crinoid and productaceans, thinly laminated to indistinct bedding, most washed out while coring, dark yellowish orange (10Y R6/6). (Lake Neosho Sh. Mbr.)	10
C	Oncolitic biomicrite, 7.5 cm of biomicrite including large 3.5 cm Osagia coated Composita, thinly laminated, organic seams undulatory, brownish shale parting washed away in coring, calcareous core grayish orange pink (5YR7/2), sharp contact with unit below	13
D	Ostracode, crinoid, productacean, foraminifer, Osagia, ectoproct bearing biomicrite, recrystallized, ferruginous, bored and burrowed, upper 45 cm extensively bored, bedding thinly laminated to indistinct, yellowish gray (5Y8/1) to light gray (N7), iron stained particularly localized to bore holes, few organic seams at base, lower 26 cm is gradational contact to interval below	67
E	Chaetetes, ectoproct, crinoid, ostracode, sphere brachiopod, foraminifer bearing biomicrite, light gray (N7) to medium dark gray (N4), contains organic seams up to 5 mm thick, Chaetetes in fragments and as whole specimens, laminae wavy particularly organic seams, above chaetetid fragments, fractures filled with calcite, rounded intraclasts, some boring	

Scale 1:10	No.	Sample No.	Sec.	T.	S. R.	County	Date



}-CL7-F

F

Locality Description:

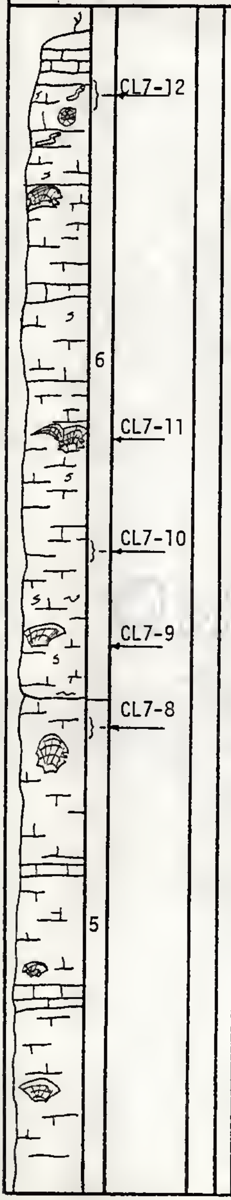
Locality Number: CL7core

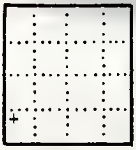
Measured by:

Remarks: Page 2 of 2

No.	Description	Thickness (cm)
	and burrowing features, sharp contact with unit below....................................	57
F	Phylloid algae, crinoid, ectoproct, foraminifer, <u>Composita</u>, <u>Osagia</u>, productaceans, pelloid ostracode bearing biomicrite, ferruginous, dolomitic(?), recrystallized, some skeletal grains preferentially dissolved, thinly laminated, organic seams undulatory, microfractures infilled with sparry calcite, few intraclasts (Osagia?) along bedding planes, geopetal structures, very porous, pale yellowish brown (10YR6/2)...........................	33
	Total Thickness of core..................	255
	Total Thickness of Amoret Ls. Mbr.........	170

Scale 1:10 No. Sample No. Sec.11 T. 35S. R. 18 E County Labette Date 7/22/76

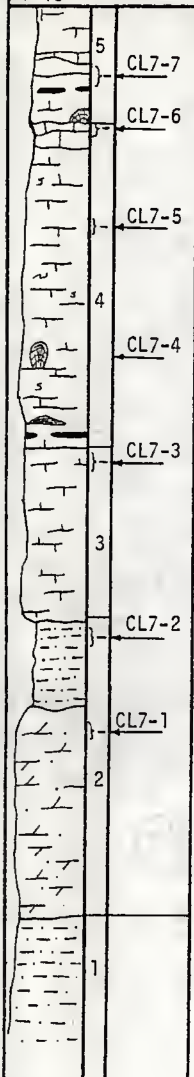




Locality Description: SW¼, SW¼, SW¼,
Elevation of basal contact: 262.5 m (861.2')
Locality Number: CL7
Measured by: James E. Mathewson
Remarks: Section along road cut on both sides of road near center of west line.

No.	Description	Thickness (cm)
6	Chaetetes, crinoid, phylloid algae, fusulinid, bearing biomicrite, recrystallized, ferruginous, pale yellowish brown (10YR6/2) weathers to moderate yellowish brown (10YR6/4), bedding indistinct, weathers massive (3-30 cm), gradational contact with unit below, chaetetids in mounds interspersed throughout this interval, large chaetetids up to 50 cm in diameter, good outcrop, covered above, sample CL7-10 taken 30 cm above base, CL7-11 taken of chaetetid mound 5 cm above previous sample. CL7-12 taken at top of this interval, CL7-13 chaetetid mound..	124
5	Chaetetes, phylloid algae, brachiopod, crinoid, fusulinid, coated grain (Osagia) bearing biomicrite, recrystallized, iron stained, small fractures infilled with sparry calcite, pale yellow brown (10YR6/2) weathers to pale yellow orange (10YR8/6), indistinct laminae, bedding varies from 1-20 cm, chaetetids in form of mounds or columns closely spaced, bioturbated (boring and burrowing features), approximately 10 cm above base is chert in form of nodules or lenses containing fusulinids, crinoids, good outcrop, samples CL7-7 chert nodule, CL7-8 from top of this interval, CL7-9 chaetetid from this interval............	118
4	Chaetetes, phylloid algae, brachiopod, gastropod, fusulinid, crinoid bearing biomicrite, recrystallized, ferruginous, earthy (?), pale yellowish brown (10YR6/2) weathers to dark yellowish orange (10YR6/6), chaetetids in columns but not abundant, laminae indistinct, irregular bedding (1-15 cm), at the base of this interval is 2-8 cm band and nodular chert 8-80 cm long, chert contains fusulinids, crinoids, algae, echinoids, horn coral, other bedding features indistinct, good outcrop, sample CL7-5, 43 cm above base, CL7-6 at top of this interval..................................	60
3	Brachiopod, Kozlowskia, phylloid algae, fusulinid,	

Scale 1:10 | No. | Sample No. | Sec. | T. | S. R. | County | Date

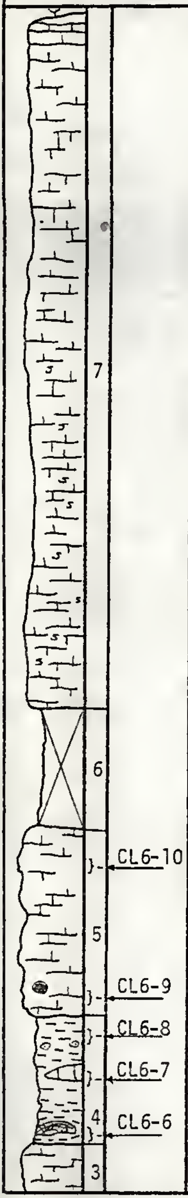


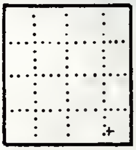
Locality Description:

Locality Number: CL7
Measured by:
Remarks: Page 2 of 2

No.	Description	Thickness (cm)
	gastropod, coated grain, oolite(?), bearing biomicrite, olive gray (5Y4/1) weathers to dark yellowish orange (10YR6/6), recrystallized, ferruginous, massive bedding, laminae indistinct, fossils abundant and finely comminuted, contact with unit above sharp, also contains *Composita* and horn corals, sample CL7-3 taken at top of this interval........................	33
2	Recrystallized, ferruginous, micrite (lower 40 cm) medium dark gray (N4), weathers to grayish orange (10YR7/4), unfossiliferous, massive bedding, laminae indistinct, some bedding surfaces mottled black and orange, fair to good outcrop, samples CL7-1 at top of this micrite interval, upper 17.5 cm is a calcareous shale, thinly laminated (2 mm or less) laminae are grayish black (N2) and light olive gray (5Y5/2) weathers to yellowish gray (5Y7/2) and medium dark gray (N4), poor outcrop, sharp contact with unit above and below, sample CL7-2 taken at upper contact..................	57
1	Shale, mottled, moderate yellowish brown (10YR 5/4) and dark yellowish brown (10YR4/2), weathers to grayish orange (10YR7/4), thin wavy bedding (less than 1 cm) unfossiliferous, poor outcrop, iron stained along bedding, some black organic debris along bedding, silty texture..	40
	Total Thickness.......................	432
	Total Thickness of Amoret Ls. Mbr.......	392

Scale 1:10 No. Sample No. Sec. 36 T. 35 S. R. 18 E County Labette Date 7/20/76





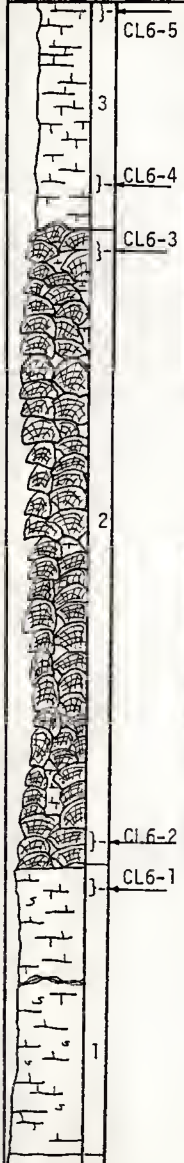
Locality Description: SW¼, SE¼, SE¼
Elevation of base: 282.74 m (927')
Locality Number: CL6
Measured by: James E. Mathewson
Remarks: Abandoned quarry, quarry face orientation N87E

No.	Description	Thickness (cm)
7	Composita, algae, crinoid, ectoproct, Derbyia, Neochonetes, echinoid bearing biomicrite, earthy, recrystallized, fractured, filled with sparry calcite and siderite, pale yellowish brown (10YR6/2) weathers to mottled dark yellowish orange (10YR6/6) and light gray (N7), bedding massive (4 to 20 cm), good outcrop, bedding irregular undulatory, no chaetetids observed, laminae indistinct, samples CL6-11 at base........................	130
6	Covered..	23
5	Neochonetes, Kozlowskia, algae, crinoid, oncolite bearing biomicrudite, light brownish gray (5YR6/1) weathers to moderate yellowish brown (10YR5/4), recrystallized, ferruginous fractured, filled with sparry calcite and siderite, massive laminae and bedding indistinct, sharp contact with unit above and below, no chaetetids except some that have grown from interval below, wavy bedding particularly where it overlies Chaetetes, fair outcrop, samples taken at base and top of this interval CL6-9 and CL6-11................	36
4	Shale with limestone lenses, shale mainly upper and lower 5 cm, shale black (N1) weathers to medium light gray (N6), limestone is medium light gray (N5), shale laminae 1-5 mm thick, shale parting varies between 1-8 cm, limestone lenses composed of Kozlowskia and other brachiopods, crinoids, fusulinids and algal coated skeletal fragments, shale contains nodules of algal-coated skeletal fragments (oncolites), fair to poor outcrop, upper contact sharp and irregular, samples taken of upper and lower shale and middle limestone, CL6-6, 7, and 8.....................	25
3	Chaetetes, algae, brachiopod bearing biomicrite, pinkish gray (5YR8/1) weathers to light olive gray (5Y6/1), recrystallized, ferruginous, fractured, sparry calcite and siderite filling	

Scale	Sample No.	Sec.	T.	S. R.	County	Date

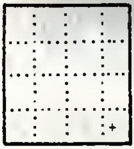
Locality Description:

Locality Number: CL6
Measured by:
Remarks: Page 2 of 2

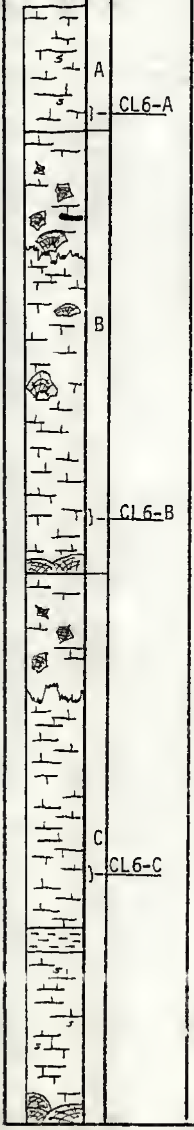


No.	Description	Thickness (cm)
	fractures, few carbonaceous seams, massive, bedding and laminae indistinct, chaetetids not as abundant as interval below although some of the mounds extend into this interval, sharp regular contact above, samples from top and base CL6-4 and CL6-5........................	53
2	Brachiopod, crinoid, fusulinids, *Chaetetes* bearing biolithite, olive gray (5Y4/1), weathers to light olive gray (5Y6/1), recrystallized, fractured with sparry calcite and siderite infillings, ferruginous, indistinct laminae and bedding, fusulinid zone possibly lower 15 cm of this interval but indistinct, black (N1) carbonaceous seams irregularly interspersed throughout, limestone made up of *Chaetetes* with very little mud, chaetetid columns dominate, carbonaceous seams contain fusulinids, crinoids and indet. skeletal debris, organic seams surrounding chaetetids and infilling cracks, small fractures on chaetetid surfaces infilled with matrix. Samples CL6-2 and 3 taken at top and base of this interval, upper contact gradational.............	123
1	Lower 8 cm below water line, algae, horn coral, brachiopod, foraminifer bearing biomicrudite, ferruginous, recrystallized, fractured with sparry calcite and siderite infillings, pale yellowish brown (10YR6/2) weathers to light olive gray (5Y5/2), bedding indistinct, contact above sharp but undulatory, fair outcrop, chaetetids not observed, 34 cm above base are thin carbonaceous seams less than 0.5 cm thick containing fusulinids and wavy bedded, samples CL6-1 taken at top of this interval..	56
	Total Thickness..........................	446
	Total Thickness of Amoret Ls. Mbr.......	293

Scale 1:10 **No.** **Sample No.** **Sec.** 36 **T.** 35 **S.** **R.** 18 E **County** Labette **Date** 5/13/77



Locality Description: SW¼, SE¼, SE¼
Elevation of Base: 283.11 m (928.8')
Locality Number: CL6core
Measured by: James E. Mathewson
Remarks: Core location is 70 m S46E of measured section CL6



No.	Description	Thickness (cm)
A	Gastropod, intraclast, brachiopod, ostracode bearing biomicrite, yellowish gray (5Y 7/2) to dark yellowish brown (10YR4/3), clasts up to 0.6 cm in diameter, highly bioturbated, bored and burrowed, indistinct bedding or laminae, iron stained and siderite infilling some of burrows, others filled with sparry calcite, gradational contact (within 12 cm) below..................................	24
B	*Chaetetes*, *Osagia*, gastropod, foraminifer, crinoid, fusulinid, brachiopod, ostracode, sphere(?), chert bearing biosparite, light gray and medium light gray (N7 and N6), bioturbated, chaetetids fractured or brecciated, siderite or sparry calcite infilling voids, geopetal structures, sharp contact below.......	85
C	*Chaetetes*, brachiopod, foraminifer, sphere(?), sponge, *Osagia*, phylloid algae, crinoid, horn coral bearing biomicrite, ferruginous, indistinct bedding, pale yellowish brown (10YR6/2), chaetetids brecciated, whole skeletons of chaetetids bored and fractured and infilled with sparry calcite, brecciated debris form pores which have been filled with sparry calcite, from 169 to 173.5 cm (from top of core) is a shale interval mostly destroyed by coring, shale interval pale yellowish brown (10YR6/2), interruption partings consisting of sparry calcite, sharp contact below at base of chaetetid lens..................................	106
D	*Chaetetes*, phylloid algae, sphere(?), gastropod, intraclast, stylolite, ectoproct bearing biomicrite, light olive gray (5Y6/1) to olive gray (5Y4/1), recrystallized, organic seams and stylolites in this interval, chaetetid fragments with sparry calcite infilling voids, some evidence of boring organisms, two types of carbonate 1) fine lithographic calcite (possibly intraclast) and 2) sparry calcite and skeletal grain debris filling voids, bedding indistinct, algae subparallel to	

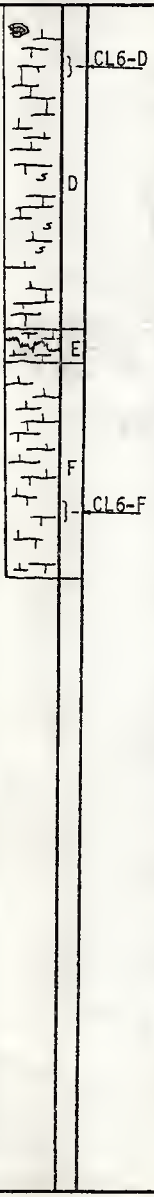
Scale 1:10	No.	Sample No.	Sec.	T.	S. R.	County	Date

Locality Description:

Locality Number: CL6core

Measured by:

Remarks: Page 2 of 2



No.	Description	Thickness (cm)
	inferred bedding, sharp contact with interval below....................................	62
E	Fusulinid, foraminifer, ectoproct, <u>Osagia</u>, brachiopod bearing biomicrite, brownish gray (5YR4/1), recrystallized, bedding indistinct, organic seams and stylolites at top of this interval, sharp contact with interval below....	6
F	Productacean, phylloid algae, <u>Osagia</u>, fusulinid, sponge, ectoproct, shpere(?), crinoid, gastropod, pelloid, worm tube bearing biomicrite, brownish gray (5YR4/1), recrystallized, fractured and filled with sparry calcite, organic seams and microstylolites in this interval with boring features, indistinct bedding but skeketal debris subparallel to inferred bedding, lower contact unobserved................	41
	Total Thickness of Amoret Ls. Mbr........	324

APPENDIX II

Data from X-ray Diffraction and Insoluble Residue Analyses

This appendix contains x-ray diffraction and insoluble residue analyses data from samples collected at the three localities (Appendix I). Sample numbers correspond to those indicated on the measured sections.

Locality CM1

Sample Number	Calcite / Quartz	Calcite / Dolomite	Mole % $MgCO_3$ in Calcite	Mole % Ca in Dolomite	Insoluble Residue
CM1-16	5.27	27.50	1.0	59.20	18.36
CM1-14	0.42	1.44	0.0	59.30	55.65
CM1-12	2.06	1.15	1.0	61.40	9.67
CM1-12	35.53	12.69	0.4	59.80	3.70
CM1-11	34.67	28.11	1.0	61.70	3.02
CM1-8	42.74	18.59	0.4	61.70	3.23
CM1-9	67.42	67.42	0.4	62.30	2.69
CM1-7	106.60	22.39	0.4	61.40	2.59
CM1-4	123.30	72.50	0.0	61.40	1.24
CM1-3	22.09	15.46	0.0	60.60	3.44
CM1-1	41.05	55.70	0.0	61.7	3.99
CM1-A	115.00	-	0.0	-	1.60
CM1-B	3.13	77.86	0.0	58.7	63.46
CM1-C	0.11	-	0.0	-	89.05
Ave.	40.05	33.40	-	60.77	13.20

Locality CL7

Sample Number	Calcite / Quartz	Calcite / Dolomite	Mole % $MgCO_3$ in Calcite	Mole % Ca in Dolomite	% Insoluble Residue
CL7-A	11.16	-	0.1	-	8.85
CL7-B	3.28	-	0.0	-	2.40
CL7-C	8.88	-	0.0	-	9.04
CL7-D	15.07	9.04	0.0	60.4	16.94
CL7-E	40.00	93.30	0.0	52.2	21.97
CL7-12	6.23	-	0.0	-	6.04
CL7-11	20.00	-	0.0	-	4.86
CL7-10	37.60	-	0.0	-	2.64
CL7-8	137.50	-	0.0	-	0.89
CL7-5	90.90	-	0.0	-	1.54
CL7-4	14.35	-	0.0	-	8.36
CL7-3	37.33	-	0.0	-	2.84
CL7-2	0.27	-	0.0	-	90.55
CL7-1	0.22	0.15	0.2	58.4	43.75
Ave.	25.7	34.20	0.15	38.9	16.30

Locality CL6

Sample Number	Calcite / Quartz	Calcite / Dolomite	Mole % $MgCO_3$ in Calcite	Mole % Ca in Dolomite	% Insoluble Residue
CL6-11	1.33	-	0.0	-	22.15
CL6-10	1.57	31.82	0.0	60.7	34.51
CL6-9	5.25	28.59	0.0	60.7	16.28
CL6-7	19.63	89.44	0.0	59.8	6.10
CL6-6	0.34	4.80	0.0	58.0	79.65
CL6-5	46.67	-	0.0	-	2.67
CL6-4	14.62	-	0.0	-	9.83
CL6-3	20.45	7.11	0.0	61.1	4.07
CL6-2	100.00	20.83	0.0	59.5	1.09
CL6-1	94.84	89.88	0.0	59.5	1.42
CL6-A	34.20	-	0.1	-	15.46
CL6-B	11.93	170.00	0.0	56.8	4.88
CL6-C	38.82	14.75	0.0	60.5	17.70
CL6-D	101.86	-	0.0	-	1.21
CL6-F	60.71	-	0.0	-	2.20
Average	36.8	50.80	-	59.6	14.10

Chaetetid Sample CM1-F18

Sample Number	$\frac{\text{Calcite}}{\text{Quartz}}$	$\frac{\text{Calcite}}{\text{Dolomite}}$	Mole % $MgCO_3$ in Calcite	Mole % Ca in Dolomite	% Insoluble Residue
CM1-F18	8.4	9.8	0.8	60.5	15.20

APPENDIX III

Thin Sections

Thin section numbers correspond to samples noted on measured sections (Appendix I). Point counts using the technique described by Chayes (1949) were carried out on each of 18 slides. Approximately 700 points, in a 1" X 3/4" area, were counted on each of 18 slides (marked *). At least 100 points along a transect on each of six slides were counted to determine percentages of: 1) micrite, 2) microspar, 3) spar, and 4) allochems (Analysis 1). A second transect, on those same six slides, (Analysis 2) was made to determine percentages of skeletal grains (marked **). Three slides (marked ***) were only briefly described.

Folk's (1974) textural classification and grain size scale were used to name the limestone.

Thin section data are arranged by 1) locality and 2) stratigraphic position. The following table shows the technique used for each slide.

Chayes (1949) Method	700 Point Method	100 Point Method	Brief Description
CM1-16	CL7-12	CL7-A	CL7-2
CM1-13	CL7-11	CL7-C	CL7-1
CM1-12	CL7-10	CL7-E	CL7-4
CM1-11	CL7-8	CL6-B	
CM1-8	CL7-5	CL6-C	
CM1-7	CL7-4	CL6-E	
CM1-3	CL7-3		
CM1-1	CL6-F		
CM1-A			
CM1-B			
CM1-C			
CL6-11			
CL6-10			
CL6-9			
CL6-7			
CL6-3			
CL6-2			
CL6-1			

CM1-16

Rock Name: Medium calcarenite, immature, recrystallized, *Osagia*, brachiopod, foraminifer, echinoid bearing biomicrite. IIb:La

Orthochems - 72.79	Points	Percentages
Micrite	499	35.54
Microspar	421	29.99
Spar	92	6.55
Quartz	7	0.50
Dolomite	3	0.21
Allochems - 27.20		
Indet. Skeletal Grains	180	12.82
Osagia	91	6.48
Brachiopods	29	2.06
Foraminifers	27	1.92
Echinoderms	22	1.57
Ectoprocts	16	1.14
Calcispheres	10	0.71
Gastropods	3	0.21
Ostracodes	2	0.14
Trilobites	2	0.14
Total	1404	99.98

Average Allochem Size: 0.367 mm

CM1-13

Rock Name: Medium calcarenite, immature, recrystallized, foraminifer, calcisphere, opthalmid, ostracode bearing dolomitic biomicrite. IIb:La

Orthochems - 78.45	Points	Percentages
Micrite	596	41.56
Microspar	264	18.41
Spar	143	9.97
Dolomite	45	5.36
Pocket Spar	77	5.36
Allochems - 21.55		
Indet. Skeletal Grains	213	14.58
Indet. Foraminifers	45	3.14
Calcispheres	15	1.05
Opthalmids	10	0.70
Ostracodes	8	0.56
Crinoids	8	0.56
Ectoprocts	6	0.42
Endothyrids	4	0.28
Total	1434	100.00

Average Allochem Size: 0.297 mm

CM1-12

Rock Name: Medium calcarenite, immature, recrystallized, calcisphere, ostracode, foraminifer, gastropod bearing dolomitic biomicrite. IIb:La

Orthochems - 84.5	Points	Percentages
Micrite	739	53.05
Microspar	170	12.20
Spar	25	1.79
Spar Pockets	185	13.28
Dolomite	44	3.16
Pocket Spar	16	1.14
Quartz	2	0.14
Allochems - 15.4		
Indet. Skeletal Grains	175	12.56
Calcisphere	10	0.72
Ostracodes	10	0.72
Foraminifers	7	0.50
Gastropods	3	0.22
Opthalmids	2	0.14
Ectoprocts	2	0.14
Bivalves	2	0.14
Echinoderms	1	0.07
Total	1393	99.97

Average Allochem Size: 0.299 mm

CM1-11

Rock Name: Coarse calcarenite, immature, recrystallized, *Osagia*, foraminifer, crinoid, phylloid algae bearing biomicrite. IIb:La

Orthochems - 68.4	Points	Percentages
Micrite	386	27.03
Microspar	319	22.33
Spar	278	19.47
Allochems - 31.5		
Indet. Skeletal Grains	171	11.97
Osagia	164	11.48
Foraminifers (Indet.)	24	1.68
Opthalmids	23	1.61
Crinoids	19	1.33
Phylloid Algae	17	1.19
Ectoprocts	13	0.91
Tuberitina	4	0.28
Ostracodes	4	0.28
Gastropods	4	0.28
Calcispheres	2	0.14
Total	1428	99.98

Average Allochem Size: 0.579 mm

CM1-8

Rock Name: Medium calcarenite, submature, recrystallized, phylloid algae. foraminifer, crinoid bearing biomicrite. IIb:La

Orthochems - 65.71	Points	Percentages
Micrite	509	31.65
Microspar	387	24.07
Spar	162	9.99
Allochems - 34.21		
Indet. Skeletal Fragments	392	24.38
Phylloid Algae	92	5.72
Foraminifers	23	1.43
Crinoids	11	0.68
Calcispheres	9	0.56
Tuberitina	7	0.44
Bivalves	5	0.31
Ectoprocts	4	0.25
Ostracodes	4	0.25
Gastropod	3	0.19
Total	1608	99.92

Average Allochem Size: 0.396 mm

CM1-7

Rock Name: Coarse calcarenite, immature, recrystallized, phylloid algae, pelloid, foraminifer, ostracode bearing biomicrosparite. IIb:La

Orthochems - 36.1	Points	Percentages
Micrite	167	11.93
Microspar	350	25.00
Spar	245	17.50
Allochems - 63.9		
Phylloid Algae (*Ivanovia* and *Eugonophyllum*)	247	17.64
Indet. Skeletal Grains	225	16.07
Pelloids	133	9.50
Indet. Foraminifer	13	0.93
Tetrataxis	6	0.43
Crinoids	6	0.43
Brachiopods	5	0.36
Ostracodes	1	0.07
Tuberitina	1	0.07
Biserial Foraminifer	1	0.07
Total	1400	100.00

Average Allochem Size: 0.541

CM1-3

Rock Name: Coarse calcarenite, submature, recrystallized, fusulinid, algae crinoid, ectoproct, brachiopod bearing biosparite. Ib:La

Orthochems - 49.82	Points	Percentages
Micrite	200	13.27
Microspar	230	15.62
Spar	321	21.30
Organic Seams	79	5.24
Allochems - 50.17		
Fusulinids	205	13.52
Indet. Skeletal Grains	140	9.29
Phylloid Algae	114	7.56
Crinoids	82	5.44
Ectoprocts	37	2.36
Foraminifers	35	2.22
Brachiopods	33	2.19
Chaetetids	12	0.79
Biserial Foraminifers	10	0.66
Ostracodes	6	0.40
Tuberitina	1	0.07
Echinoids	1	0.07
Total	1507	100.00

Average Allochem Size: 0.790 mm

CM1-1

Rock Name: Coarse calcarenite, immature, recrystallized, *Osagia*, *Ivanovia*, *Eugonophyllum*, spicule bearing biomicrite. IIb:La

Orthochems - 67.02	Points	Percentages
Micrite	490	33.04
Microspar	342	23.06
Spar	162	10.92
Allochems - 32.97		
Indet. Skeletal Grains	226	15.24
Osagia	81	5.46
Algae (*Eugonophyllum* and *Ivanovia*)	58	3.91
Spicules	47	3.17
Brachiopods	25	1.69
Ectoprocts	23	1.55
Crinoids	20	1.35
Ostracodes	4	0.27
Foraminifers	3	0.20
Tuberitina	2	0.13
Total	1483	99.99

Average Allochem Size: 0.616 mm

CM1-A

Rock Name: Medium calcarenite, immature, recrystallized, phylloid algae, *Osagia*, foraminifer, ectoproct bearing biomicrite. IIb:La

Orthochems - 60.0	Points	Percentages
Micrite	431	30.5
Microspar	319	22.58
Spar	109	7.71
Allochems - 39.9		
Indet Skeletal Grains	335	23.71
Phylloid Algae	90	6.37
Osagia	37	2.62
Foraminifers	22	1.56
Ectoporoct	19	1.34
Pelloids	17	1.20
Tuberitina	13	0.92
Echinoids	8	0.57
Spicules	5	0.35
Ostracodes	3	0.21
Calcispheres	3	0.21
Brachiopods	1	0.07
Gastropods	1	0.07
Total	1413	99.99

Average Allochem Size: 0.444 mm

CM1-B

Rock Name: Medium calcarenite, immature, recrystallized, silty, brachiopod, ectoproct, echinoderm bearing biomicrite. TzIIb:La

Orthochems - 78.6	Points	Percentages
Micrite	107	7.49
Microspar	550	38.52
Spar	43	3.01
Quartz	422	29.55
Feldspar	43	3.01
Allochems - 21.4		
Indet. Skeletal Grains	210	14.71
Brachiopods	35	2.45
Ectoprocts	14	0.98
Echinoderms	3	0.21
Ostracodes	1	0.07
Total	1428	100.00

Average Allochem Size: 0.458 mm
Average Quartz Grain Size: 0.101 mm

CM1-C

Rock Name: Very fine calcarenite, immature, recrystallized, silty, micrite.
Tz II:La

Orthochems - 98.4	Points	Percentages
Micrite	725	52.23
Quartz	591	42.58
Collophane	20	1.44
Glauconite	18	1.30
Feldspar	12	0.86
Allochems - 1.6		
Indet. Skeletal Grains	2	0.14
Organics (Tar)	20	1.44
Brachiopods	Present	0.00
Echinoids	Present	0.00
Ostracodes	Present	0.00
Total	1388	99.99

Average Quartz Grain Size: 0.088 mm

CL7-A **

Rock Name: Coarse calcarenite, immature, recrystallized, phylloid algae _Osagia_, foraminifer, ostracode bearing biomicrite. IIb:La

Analysis 1

Orthochems - 65.0	Points	Percentages
Micrite	42	42.0
Microspar	12	12.0
Spar	11	11.0
Allochems	35	35.0
Total	100	100.0

Analysis 2

Allochems		
Osagia	33	31.4
Phylloid Algae	23	21.9
Indet. Skeletal Grains	18	17.0
Foraminifers	15	14.3
Ostracodes	7	6.7
Ectoprocts	5	4.8
Calcispheres	3	2.9
Crinoids	1	1.0
Total	105	100.0

Average Allochem Size: 0.502 mm

CL7-C **

Rock Name: Fine calcarenite, immature, recrystallized, foraminifer, ostracode, calcisphere, pelloid bearing biomicrite. IIb:La

Analysis 1

Orthochems - 73.2	Points	Percentages
Micrite	48	47.5
Microspar	23	22.7
Spar	3	3.0
Allochems	27	26.7
Total	101	99.9

Analysis 2

Allochems		
Indet. Skeletal Grains	54	50.0
Foraminifers	23	21.3
Ostracodes	14	12.9
Calcispheres	10	9.3
Pelloids	7	6.5
Total	108	100.0

Average Allochem Size: 0.182 mm

CL7-E **

Rock Name: Medium calcarenite, immature, recrystallized, *Osagia*, foraminifer, phylloid algae, crinoid bearing biomicrite. IIb:La

Analysis 1

Orthochems - 81.0	Points	Percentages
Micrite	52	52.0
Microspar	25	25.0
Spar	4	4.0
Allochems	19	19.0
Total	100	100.0

Analysis 2

Allochems		
Indet. Skeletal Grains	34	32.6
Osagia	19	18.3
Foraminifers	15	14.4
Phylloid Algae	13	12.5
Echinoids	10	9.6
Ostracodes	7	6.7
Ectoprocts	3	2.9
Calcispheres	2	2.0
Brachiopods	1	1.0
Total	104	100.0

Average Allochem size: 0.421 mm

CL7-12 *

Rock Name: Fine calcarenite, immature, pelloid, foraminifer, ectoproct, ostracode bearing biomicrite. IIb:La

Orthochems - 79.1	Points	Percentages
Micrite	266	37.7
Microspar	204	28.9
Spar	88	12.5
Allochems - 20.9		
Indet. Skeletal Grains	120	17.0
Pelloids	13	1.8
Foraminifers	6	0.9
Ectoprocts	4	0.6
Ostracodes	3	0.4
Crinoids	1	0.1
Total	705	99.9

Average Allochem Size: 0.217 mm

CL7-11 *

Rock Name: Medium calcarenite, immature, recrystallized, ectoproct, foraminifer, brachiopod, echinoid bearing biosparite. Ib:La

Orthochems - 79.9	Points	Percentages
Micrite	211	28.9
Microspar	134	18.4
Spar	237	32.6
Allochems - 20.1		
Indet. Skeletal Grains	61	8.4
Ectoprocts	30	4.1
Foraminifers	26	3.6
Brachiopods	12	1.6
Echinoids	7	1.0
Ostracodes	5	0.7
Pelloids	2	0.3
Gastropods	2	0.3
Calcispheres	1	0.1
Total	728	100.0

Average Allochem Size: 0.347 mm

CL7-10 *

Rock Name: Medium calcarenite, submature, recrystallized, microquartz replaced, foraminifer, ectoproct, crinoid, brachiopod bearing biosparite. Ib:La

Orthochems - 80.8	Points	Percentages
Micrite	222	31.7
Microspar	114	16.2
Spar	231	32.9
Allochems - 19.2		
Indet. Skeletal Grains	59	8.3
Foraminifers	31	4.4
Ectoprocts	17	2.4
Crinoids	9	1.3
Brachiopods	4	0.6
Ostracodes	4	0.6
Osagia	3	0.4
Phylloid Algae	3	0.4
Pelloids	2	0.3
Gastropods	2	0.3
Opthalmids	1	0.1
Total	709	99.9

Average Allochem Size: 0.323 mm

CL7-8

Rock Name: Medium calcarenite, immature, recrystallized, phylloid algae, gastropod, pelloid, echinoid bearing biomicrite. IIb:La

Orthochems - 68.6	Points	Percentages
Micrite	274	39.7
Microspar	173	25.0
Spar	28	4.0
Allochems - 31.4		
Indet Skeletal Grains	148	21.5
Phylloid Algae	19	2.7
Gastropods	11	1.6
Pelloids	10	1.4
Echinoids	7	1.0
Foraminifers	6	0.9
Ectoproct	5	0.7
Ostracodes	3	0.4
Brachiopods	3	0.4
Calcispheres	2	0.3
Spicules	2	0.3
Spheres(?)	1	0.1
Total	692	100.0

Average Allochem Size: 0.347 mm

CL7-5 *

Rock Name: Coarse calcarenite, immature, recrystallized, ferruginous, phylloid algae, *Osagia*, foraminifer, pelloid bearing biomicrite. IIb:La

Orthochems - 58.5	Points	Percentages
Micrite	179	25.6
Microspar	75	10.7
Spar	155	22.2
Allochems - 41.3		
Phylloid Algae	135	19.3
Osagia	87	12.4
Indet. Skeletal Grains	51	7.3
Foraminifers	5	0.7
Pelloids	3	0.4
Brachiopods	2	0.3
Calcispheres	2	0.3
Spicules	2	0.3
Echinoids	1	0.1
Ectoprocts	1	0.1
Ostracodes	1	0.1
Total	699	99.8

Average Allochem Size: 0.613 mm

CL7-4 *

Rock Name: Coarse calcarenite, immature, recrystallized, microquartz replaced, ferruginous, bioturbated, phylloid algae, foraminifer crinoid, ectoproct bearing biomicrite. IIb:La

Orthochems - 54.1	Points	Percentages
Micrite	255	35.8
Microspar	107	15.0
Spar	24	3.4
Allochems - 45.9		
Phylloid Algae	162	22.7
Indet. Skeletal Grains	97	13.6
Foraminifers	17	2.4
Echinoids	11	1.5
Ectoprocts	11	1.5
Spicules	10	1.4
Osagia	9	1.3
Brachiopods	4	0.6
Gastropods	3	0.4
Pelloids	2	0.3
Ostracodes	1	0.1
Total	713	100.0

Average Allochem Size: 0.506 mm

CL7-3 *

Rock Name: Coarse calcarenite, immature, recrystallized, Osagia, gastropod, phylloid algae, echinoid bearing biomicrite. IIb:La

Orthochems - 64.8	Points	Percentages
Micrite	224	36.1
Microspar	120	19.3
Spar	59	9.4
Allochems - 35.0		
Osagia	52	8.4
Indet. Skeletal Grains	49	7.8
Gastropods	29	4.7
Phylloid Algae	26	4.2
Echinoids	9	1.5
Pelloids	9	1.5
Brachiopods	9	1.5
Spicules	8	1.3
Osagia Intraclasts	8	1.3
Opthalmids	5	0.8
Foraminifers (Indet.)	5	0.8
Ectoprocts	3	0.5
Ostracodes	3	0.5
Calcispheres	2	0.3
Total	620	99.0

Average Allochem Size: 0.548 mm

CL7-2 ***

Rock Name: Quartz silty, calcareous shale with black carbonaceous seams,
Less than 5% skeletal grains
Iron stained
Quartz grains angular to subangular
Average quartz grain size - 0.031 mm
Phosphatic skeletal debris
Microquartz replaced skeletal grains

CL7-1 ***

Rock Name: Quartz silty, ostracode bearing finely crystalline replaced dolomite. V:03

Dolomite crystal size: 0.035 mm
Quartz grain size: 0.025 mm

CL6-11

Rock Name: Coarse calcarenite, immature, recrystallized, silty, iron stained, microquartz replaced, crinoid, ectoproct, brachiopod, spicule bearing biomicrosparite. IIb:La

Orthochems - 63.0	Points	Percentages
Micrite	294	20.8
Microspar	411	29.1
Spar	177	12.5
Quartz	9	0.6
Allochems - 37.0		
Crinoids	215	15.2
Ectoproct	112	7.9
Pseudopunctate Brachs.	95	6.7
Other Brachiopods	42	3.0
Indet. Skeletal Grains	37	2.6
Spicules	8	0.6
Phylloid Algae	4	0.3
Ostracodes	4	0.3
Foraminifers	4	0.3
Osagia	2	0.1
Total	1414	100.0

Average Allochem Size: 0.794 mm

CL6-10

Rock Name: Coarse calcarenite, immature, recrystallized, microquartz replaced, ferruginous, silty, Osagia, phylloid algae, brachiopod pelloid bearing biosparite. IIb:La

Orthochems - 63.9	Points	Percentages
Micrite	224	16.0
Microsparite	426	30.4
Spar	218	15.6
Quartz	26	1.9
Allochems - 36.1		
Osagia	218	15.6
Indet. Skeletal Grains	89	6.4
Phylloid Algae	77	5.5
Brachiopods	42	3.0
Pelloids	33	2.4
Foraminifers	17	1.2
Echinoids	14	1.0
Ostracodes	5	0.4
Ectoprocts	4	0.3
Calcispheres	3	0.2
Spicules	2	0.1
Total	1398	99.9

Average Allochem Size: 0.573 mm

CL6-9

Rock Name: Medium calcarenite, immature, recrystallized, microquartz replaced, bioturbated, pelloid, spicule, echinoid, brachiopod bearing biomicrosparite. IIb:La

Orthochems - 72.1	Points	Percentages
Micrite	271	19.4
Microspar	577	41.3
Spar	159	11.4
Allochems - 27.9		
Pelloids	144	10.3
Indet. Skeletal Grains	85	6.1
Spicules	60	4.3
Echinoderms	44	3.1
Brachiopods	27	1.9
Osagia	17	1.2
Foraminifers	7	0.5
Ectoprocts	6	0.4
Calcispheres	1	0.1
Total	1398	100.0

Average Allochem Size: 0.483 mm

CL6-7

Rock Name: Coarse calcarenite, immature, recrystallized, *Osagia*, brachiopod, foraminifer, crinoid bearing biomicrite. IIb:La

Orthochems - 59.1	Points	Percentages
Micrite	416	28.4
Microspar	411	28.2
Spar	36	2.5
Allochems - 40.9		
Indet. Skeletal Grains	198	13.5
Osagia	133	9.1
Brachiopods	98	6.7
Foraminifers	32	2.2
Echinoids	30	2.1
Spicules	27	1.8
Pelloids	20	1.4
Intraclasts	20	1.4
Gastropods	13	0.9
Ectoprocts	10	0.7
Ostracodes	6	0.4
Phylloid Algae	6	0.4
Spar Holes (?)	2	0.1
Calcispheres	1	0.1
Trilobites	1	0.1
Total	1460	100.0

Average Allochem Size: 0.576 mm

CL6-4 ***

Rock Name: Coarse calcarenite, immature, recrystallized, echinoid, foraminifer, ectoproct, productacean, intraclast, pelloid, crinoid, ostracode, calcisphere bearing biomicrite. IIb:La

Average Allochem Size: 0.536 mm

CL6-3

Rock Name:Medium calcarenite, immature, recrystallized, ferruginous, _Osagia_, foraminifer, echinoid, ectoproct bearing biomicrosparite. IIb:La

Orthochems - 65.9	Points	Percentages
Micrite	304	21.6
Microspar	400	28.4
Spar	223	15.9
Allochems - 34.1		
Indet. Skeletal Grains	354	25.2
Osagia	56	4.0
Foraminifers	29	2.1
Echinoids	17	1.2
Ectoprocts	8	0.6
Ostracodes	6	0.4
Spar Holes (?)	4	0.3
Calcispheres	3	0.2
Brachiopods	1	0.1
Total	1405	100.0

Average Allochem Size: 0.387 mm

CL6-2

Rock Name: Coarse calcarenite, immature recrystallized, ferruginous,echinoid, _Osagia_, foraminifer, ectoproct bearing biomicrosparite. IIb:La

Orthochems - 65.1	Points	Percentages
Micrite	332	23.4
Microspar	480	33.8
Spar	112	7.9
Allochems - 34.9		
Indet. Skeletal Grains	313	22.1
Spar Holes (?)	66	4.7
Echinoids	35	2.5
Osagia	33	2.3
Foraminifers	21	1.5
Ectoprocts	14	1.0
Ostracodes	6	0.4
Calcispheres	3	0.2
Gastropods	2	0.1
Brachiopods	2	0.1
Total	1419	100.0

Average Allochem Size: 0.597 mm

CL6-1

Rock Name: Medium carcarenite, immature, recrystallized, ferruginous, organic seams, *Osagia*, foraminifer, gastropod, ectoproct bearing biomicrite. IIb:La

	Points	Percentages
Orthochems - 64.1		
Micrite	429	29.5
Microspar	308	21.2
Spar	194	13.4
Allochems - 35.9		
Indet. Skeletal Grains	304	20.9
Osagia	150	10.3
Foraminifers	32	2.2
Gastropods	16	1.1
Ectoprocts	10	0.7
Crinoids	5	0.3
Ostracodes	5	0.3
Total	1453	99.9

Average Allochem Size: 0.371

CL6-B **

Rock Name: Medium calcarenite, submature, recrystallized, bioturbated, foraminifer, *Osagia*, worm tube, opthalmid bearing biosparite. Ib:La

Analysis 1

	Points	Percentages
Orthochems - 77.0		
Micrite	29	29.0
Microspar	13	13.0
Spar	35	35.0
Allochems	23	23.0
Total	100	100.0

Analysis 2

Allochems		
Indet. Skeletal Grains	29	27.6
Foraminifers	27	25.7
Osagia	10	9.4
Worm Tubes	7	6.6
Ostracodes	7	6.6
Opthalmids	6	5.7
Chaetetids	5	4.8
Crinoids	5	4.8
Pelloids	5	4.8
Calcispheres	2	2.0
Ectoprocts	1	1.0
Gastropods	1	1.0
Total	105	100.0

Average Allochem Size: 0.371 mm

CL6-C **

Rock Name: Medium calcarenite, immature, recrystallized, ferruginous, foraminifer, echinoid, ectoproct bearing biomicrite. IIb:La

Analysis 1

Orthochems - 72.0	Points	Percentages
Micrite	44	44.0
Microspar	13	13.0
Spar	15	15.0
Allochems	28	28.0
Total	100	100.0

Analysis 2

Allochems		
Indet. Skeletal Grains	64	54.7
Foraminifers	14	12.0
Echinoids	12	10.2
Ectoprocts	8	6.8
Osagia	7	6.0
Ostracodes	6	5.1
Phylloid Algae	3	2.6
Pelloids	2	1.7
Gastropods	1	0.8
Total	117	99.9

Average Allochem Size: 0.392 mm

CL6-E **

Rock Name: Coarse calcarenite, immature, recrystallized, phylloid algae, foraminifer, Osagia, crinoid bearing biomicrite. IIb:La

Analysis 1

Orthochems - 59.0	Points	Percentages
Micrite	26	26.0
Microspar	22	22.0
Spar	11	11.0
Allochems	41	41.0
Total	100	100.0

Analysis 2

Allochems		
Indet. Skeletal Grains	43	37.0
Phylloid Algae	35	30.2
Foraminifers	16	13.8
Osagia	11	9.5
Crinoids	6	5.2
Ectoprocts	2	1.7
Brachiopods	2	1.7
Calcispheres	1	0.9
Total	116	100.0

Average Allochem Size: 0.566 mm

CL6-F

Rock Name: Medium calcarenite, immature, recrystallized, phylloid algae, *Osagia*, foraminifer, ostracode bearing biomicrite. IIb:La

Orthochems - 77.9	Points	Percentages
Micrite	336	47.5
Microspar	141	19.9
Spar	74	10.5
Allochems - 22.1		
Indet. Skeletal Grains	82	11.6
Phylloid Algae	30	4.2
Osagia	17	2.4
Foraminifers	16	2.3
Ostracodes	4	0.6
Gastropods	3	0.4
Spheres(?)	2	0.3
Pelloids	1	0.1
Calcispheres	1	0.1
Opthalmids	1	0.1
Total	708	100.0

Average Allochem Size: 0.324 mm

APPENDIX IV

Oncolite Parameters

Oncolites were sieved using standard sedimentological procedures (Folk, 1974). The Ø (phi) scale was uned as a matter of convenience and conversions for this scale are included in the table.

Ø	mm	Weight (gm)	Percent	Cumulative Percent
-5	31.5	461.10	29.75	29.75
-4	16.0	894.10	57.68	87.43
-3	8.0	176.00	11.35	98.78
-2	4.0	8.80	0.57	99.34
-1.75	3.35	1.30	0.08	99.42
-1.5	2.83	0.80	0.05	99.47
-1.25	2.36	0.75	0.05	99.52
Pan		7.20	0.46	99.99
		1550.05	99.99	

Mode (M_o) = -4.0 Ø

Median (M_D) = -4.7 Ø

Graphic Mean (M_z) = -4.696 Ø

Inclusive Graphic Standard Deviation (σ_I) = 0.618 Moderately Well Sorted

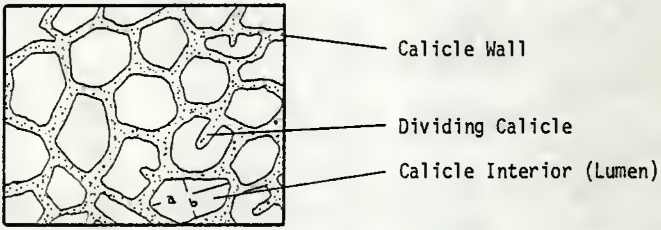
Inclusive Graphic Skewness (Sk_I) = 0.015 Near Symmetrical

Kurtosis of Peakedness (K_G) = 1.05 Platykurtic

APPENDIX V

Calicle Dimensions

Calicle dimensions were measured on 13 specimen. Both length (a) and width (b) were measured because few calicles were circular or polygonal. Calicles were separated into categories according to their arrangement and geometric configuration. "Calicles Forming Astrorhizae" refer to linearly arranged calicles which form branches of astrorhizae. Calicles in which longitudinal fission was observed were included in the category "Dividing Calicles". "Other Calicles" refers to calicles not in the process of division.



CALICLE DIMENSIONS

1. Specimen Number CL6-B, Thin Section

Calicles Forming Astrorhizae
Branch 1, n=20
Average Width = 0.224 mm   Width Range = 0.106 - 0.356 mm
Average Length = 0.405 mm   Lenght Range = 0.267 - 0.498

Branch 2, n = 9
Average Width = 0.220 mm   Width Range = 0.178 - 0.284 mm
Average Length = 0.348 mm   Length Range = 0.284 - 0.391 mm

Branch 3, n = 9
Average Width = 0.263 mm   Width Range 0.213 - 0.320 mm
Average Length = 0.366 mm   Length Range = 0.320 - 0.462 mm

Dividing Calicles n = 29
Average Width = 0.302 mm   Width Range = 0.179 - 0.427 mm
Average Length = 0.388 mm   Length Range = 0.249 - 0.462 mm

Other Calicles n = 48
Average Width = 0.245 mm   Width Range = 0.142 - 0.356 mm
Average Length = 0.338 mm   Length Range = 0.178 - 0.567 mm

2. Specimen Number CL7-11, Thin Section

Dividing Calicles n = 15
Average Width = 0.313 mm   Width Range = 0.216 - 0.432 mm
Average Length = 0.413 mm   Length Range = 0.332 - 0.476 mm

Other Calicles
Average Width = 0.262 mm   Width Range = 0.130 - 0.404 mm
Average Length = 0.394 mm   Length Range = 0.187 - 0.533 mm

3. Specimen Number CM1-3, Thin Section

Dividing Calicles n = 15
Average Width = 0.299 mm   Width Range = 0.143 - 0.388 mm
Average Length = 0.329 mm   Length Range = 0.173 - 0.459 mm

Other Calicles n = 20
Average Width = 0.187 mm   Width Range = 0.122 - 0.326 mm
Average Length = 0.286 mm   Length Range = 0.133 - 0.530 mm

4. Specimen Number CM1-5, Thin Section

Dividing Calicles n = 4
Average Width = 0.252 mm   Width Range = 0.194 - 0.306 mm
Average Length = 0.308 mm   Length Range = 0.224 = 0.408 mm

Other Calicles n = 15
Average Width = 0.230 mm   Width Range = 0.153 - 0.357 mm
Average Length = 0.293 mm   Length Range = 0.204 = 0.408 mm

CALICLE DIMENSIONS (cont.)

5. Specimen Number CM1-3, Thin Section

Dividing Calicles n = 2
Average Width = 0.250 mm Width Range = 0.235 - 0.265 mm
Average Length = 0.500 mm Length Range 0.428 - 0.571 mm

Other Calicles n = 26
Average Width = 0.230 mm Width Range = 0.082 - 0.367 mm
Average Length = 0.305 mm Length Range = 0.112 - 0.510 mm

6. Specimen Number CM1-F39, Peel

Dividing Calicles n = 6
Average Width = 0.241 mm Width Range = 0.173 - 0.275 mm
Average Length = 0.362 mm Length Range = 0.296 - 0.408 mm

Other Calicles n = 18
Average Width = 0.223 mm Width Range = 0.112 - 0.296 mm
Average Length = 0.309 mm Length Range = 0.194 - 0.541 mm

7. Specimen Number CM1-23, Peel

Dividing Calicles n = 6
Average Width = 0.180 mm Width Range = 0.122 - 0.224 mm
Average Length = 0.340 mm Length Range = 0.286 - 0.398 mm

Other Calicles n = 29
Average Width = 0.199 mm Width Range = 0.133 - 0.265 mm
Average Length = 0.269 mm Length Range = 0.194 - 0.377 mm

8. Specimen Number CM1-F18, Peel

All Calicles n = 6
Average Width = 0.143 mm Width Range = 0.122 - 0.163 mm
Average Length = 0.202 mm Length Range = 0.163 - 0.245 mm

9. Specimen Number CM1-F42, Polished Surface

All Calicles n = 6
Average Width = 0.202 mm Width Range = 0.173 - 0.235 mm
Average Length = 0.267 mm Length Range = 0.214 - 0.347 mm

10. Specimen Number CM1-F25, Polished Surface

All Calicles n = 8
Average Width = 0.133 mm Width Range = 0.107 - 0.178 mm
Average Length = 0.267 mm Length Range = 0.107 - 0.356 mm

11. Specimen Number CM1-F45, Polished Surface

CALICLE DIMENSIONS (cont.)

All Calicles n = 11
Average Width = 0.190 mm Width Range = 0.101 - 0.303 mm
Average Length = 0.270 mm Length Range = 0.130 - 0.433 mm

12. Specimen Number CM1-F39, Polished Surface

All Calicles n = 12
Average Width = 0.225 mm Width Range = 0.130 - 0.404 mm
Average Length = 0.318 mm Length Range = 0.173 - 0.490 mm

13. Specimen Number CL6-C, Polished Core

All Calicles n = 3
Average Width = 0.176 mm Width Range = 0.153 - 0.204 mm
Average Length = 0.273 mm Length Range = 0.214 - 0.306 mm

APPENDIX VI

Features of Individual Chaetetids

1. Specimen Number
   Specimen numbers designate locality, in situ or float (F), and a number. (*e. g.* CM1-F5 chaetetid specimen number 5, collected as float from locality CM1)
   All float samples probably came from the shale at the top of the measured section because this was the only place they could have weathered free of surrounding matrix.

2. Type of Preperation
   P - cut and polished surface, H - whole specimen, B - broken specimen

3. Growth Form
   S - shingles, M - mounds, C - columns

4. Eroded Top
   P - present

5. Substrate
   C - *Composita*, O - *Osagia* oncolite, P - productacean, S - spiriferacean, SF - skeletal fragment (unidentifiable), Cl - (Clay) lithologic fragment, or combinations, *e. g.* CO - *Composita* covered by an *Osagia* oncolite , or Ss. siltstone substrate.

6. Extent of encrustation
   T - only the upper surface encrusted, B - both upper and lower surfaces encrusted

7. Fractures (internal and external)
   P - present, IF - internal fractures present

8. Barnacle Borings
   P - present

9. Astrorhizae
   P - present, IA - internal astrorhizae

10. Surface Debris
    P - skeletal grains, *Osagia* or matrix coating chaetetid surface

11. Tabulae
    A - abundant, conspicuous tabulae throughout specimen
    R - rare, tabulae not conspicuous but can be observed in less than 10% of the calicles

12. Interruption Partings
    P - present

13. "Worm Tubes" Skeletal Deformation
    P - Skeletal deformation observed, due to worm tubes or skeletal fragments

14. Borings
    P - borings observed in skeleton

15. Spicules
    P - present in skeleton

16. Width (cm)

17. Length (cm)

18. Height (cm)

A blank in the space indicates that the particular feature was not present or could not be observed.

Features of Individual Chaetetids

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CM1-17	P	S		S, C1	T				P	A	P				3.0	6.0	4.0
CM1-18	P	S		P, 0	T				P	A	P				4.6	4.7	2.2
CM1-19	P	C		SF, C1	B	P	P		P	R	P	P			9.2	18.5	12.3
CM1-20	P	C		P, C1	8	P	P		P	R	P				10.0	12.0	17.0
CM1-21	P	S		P, 0, C1	T				P	A	P				4.5	5.4	1.7
CM1-22	P	S		P, 0, C1	T				P	A	P	P			5.2	5.2	2.3
CM1-23	P	S		C, 0, C1	B	IF	P		P	A	P		P		6.6	7.0	4.5
CM1-25	P	M		C, 0, P	T				P	R	P	P	P		19.0	34.0	17.5
CM1-26	P	S		P, 0, C1	B				P	A	P				5.3	6.0	3.2
CM1-28	P	S		P, 0, C1	T				P	R	P				6.0	7.5	3.0
CM1-41	P	S		P, C1	T			P	P	A	P		P		5.0	5.3	1.5
CM1-44	H	M	P	?	B	P			P	A	P				7.5	9.0	6.0
CM1-45	H	S		P, 0	T	P		P	P	A	P				10.0	11.5	6.0
CM1-46	P	S	P	P, C, 0	B	P		P	P	A	P				10.5	15.0	7.0
CM1-47	B	S	P	Org. Pt.	T	P	P			A	P						7.0
CM1-F1	P	S & C		C, 0, P	T	P		IA	P	A	P	P	P		14.0	20.0	15.0
CM1-F3	P	S		C, 0	B				P	A	P				1.4	1.8	1.8

Features of Individual Chaetetids

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CM1-F4	P	S		Cl, O	B				P	R	P	P	P		8.0	9.0	6.0
CM1-F9	P	C	P	P, O	B				P	A	P	P			8.5	11.0	8.0
CM1-F11	P	C	P	S, Cl	B				P	A	P	P	P		6.0	8.5	5.1
CM1-F14	H	M		C, O	B	P	P		P	R	P				11.7	14.3	9.5
CM1-F15	H	M	P	S, O, C	B	P	P	P	P	A	P				14.0	16.4	9.1
CM1-F18	P	M		S, O	B	P	P		P	A	P	P	P		8.0	9.3	7.4
CM1-F21	P	S	P	SK, P, C	B	P			P	R	P	P	P		5.5	11.2	2.4
CM1-F24	H	S	P	C, P, O	B				P	A					10.5	13.0	4.0
CM1-F25	P	C	P	S, O	B	P		P	P	A	P	P	P		9.5	9.5	9.0
CM1-F26	P	C-M		P, Cl	B	P			P	A	P		P		14.0	15.0	16.5
CM1-F29	P	C-S	P	SF, O	B	P			P	A	P	P	P		11.5	12.5	14.0
CM1-F32	P	M	P	P, O, Cl	T				P	A	P	P	P		11.5	18.0	7.0
CM1-F34	H	M	P	O	B	P	P		P	R					15.0	20.0	13.0
CM1-F35	H	S	P	O, P	T				P	A	P				-	8.0	4.0
CM1-F36	H	S	P	O	B	P		P	P	?	?				17.5	23.0	8.0
CM1-F37	P	S	P	P, O, Cl	T	P	P	P	P	A	P	P	P		28.0	33.0	12.5
CM1-F38	H				T			P	P	?	?				6.0	8.5	6.0
CM1-F39	P	S	P	P, O, C	T				P	R	P	P			10.5	11.0	6.5

Features of Individual Chaetetids

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CM1-F40	H	S	P	?	B		P	P	P	A	P	P	P		22.0	24.0	13.0
CM1-F42	P	C		P, O	B	P			P	R	P	P		P	12.0		11.0
CM1-F43	H	C-M		P, O	T	P			P	A	P	P			16.2	20.0	11.2
CM1-F45	P	S-C	P	P, O	B		P	P	P	A	P	P	P		14.0	15.5	8.5
CM1-F46	P	S-M	P	P, O, Cl	B	P		P	P	A	P	P	P		18.2		12.2
CM1-F47	P	S		C, P, O	T				P	A	P				5.0	6.3	3.5
CL7-9	P	C	P	P, O	B				P	R	P	P			8.0	8.0	12.5
CL7-F17	H	M		Cl	B	P			P	A	P	P	P		13.5	15.0	12.1
CL7-F22	H	S		O	T		small patches on substrate								7.0	7.0	3.5
CL7-F23	P	S		Ss.	B	IF				R	P	P	P		11.0	14.0	8.0
CL7-F30	P	S-C			T					R	P	P			10.8	12.0	7.0
CL7-F31	P	C-M	P	P, O	T				P	A	P	P	P		8.5	14.0	9.0
CL6-16	B	M				IF			P	A		P	P		-	-	-
CL6-F2	P	M		?	B	P			P	A	P				26.0	28.0	20.0

PLATE I

Some Pertinent Features at Locality CM1

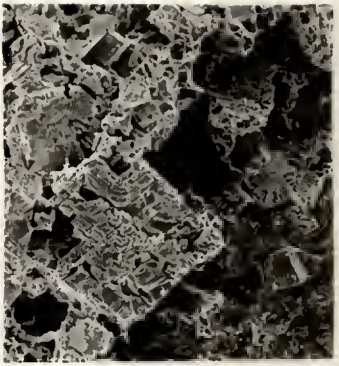
Figure 1. Dolomitization at Locality CM1 occurring in voids and fractures (light areas) between lithic fragments (dark areas); Thin section number CM1-12.

Figure 2. Dolomite rhombs in burrowed-dolomite facies at CM1; SEM photograph of sample number CM1-12.

Figure 3. Cut and polished oncolite from locality CM1 showing *Composita* nucleus and burrowed structures (arrows), Sample number CM1-14

Figure 4. Distortion of shale and limestone at locality CM1 surrounding columnal chaetetid; ruler is 17 cm long.

1



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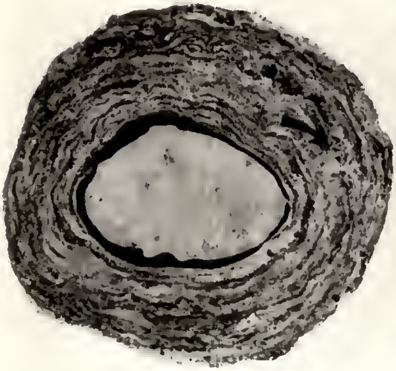

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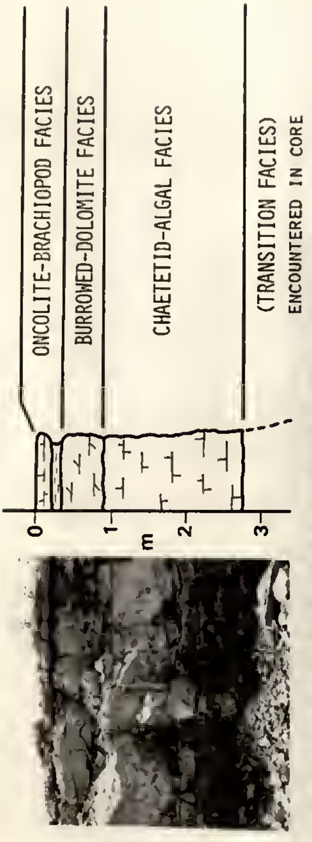
PLATE 2

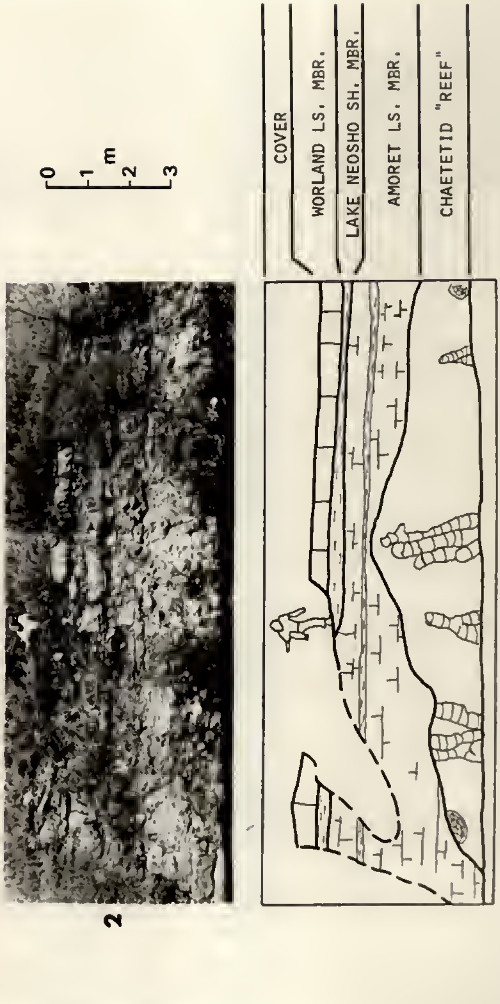
Localities CM1 and CL6

Figure 1. Locality CM1 with interpretive sketch and facies relationships.

Figure 2. Locality CL6 with interpretive sketch, note chaetetid build-up.


ONCOLITE-BRACHIOPOD FACIES
BURROWED-DOLOMITE FACIES
CHAETETID-ALGAL FACIES
(TRANSITION FACIES)
ENCOUNTERED IN CORE
0
1
2
3
m

1


0
1
2
3
m
COVER
WORLAND LS. MBR.
LAKE NEOSHO SH. MBR.
AMORET LS. MBR.
CHAETETID "REEF"

2

PLATE 3

Sedimentary Structures and Pertinent Features at Localities CM1 and CL7

Figure 1. Burrowing feature from locality CM1 showing bioturbation; Thin section number CM1-12.

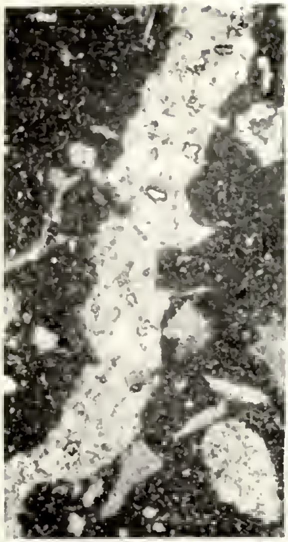
Figure 2. Burrow filled with sparry calcite and bioturbated lithic fragments from locality CM1; Thin section number CM1-12.

Figure 3. Brecciated upper contact of burrowed-dolomite facies from locality CM1, note burrowing which had been filled with sparry calcite prior to brecciation (arrow); Thin section number CM1-12

Figure 4. Shingle-form chaetetid spreading out over oncolites in upper shale in oncolite-brachiopod facies, ruler is 15 cm long; photo taken at locality CM1.

Figure 5. Dolomite rhomb replacing skeletal grains, euhedral crystals larger than 0.015 mm; Thin section number CL7-1.

Figure 6. Evidence of dolomitization in the transition facies at locality CL7, dolomite replacing skeletal grain; Thin section CL7-1.



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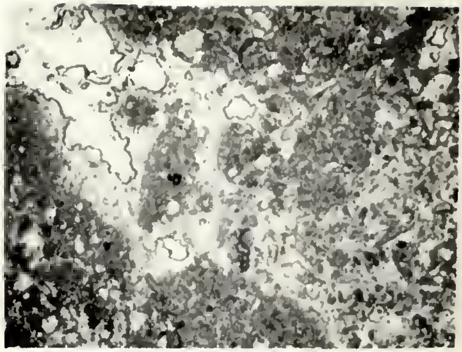

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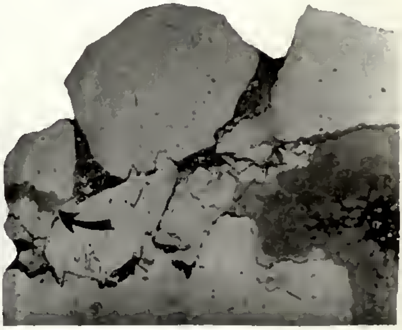

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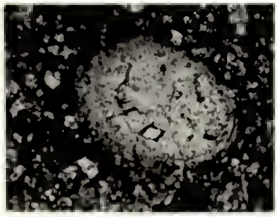

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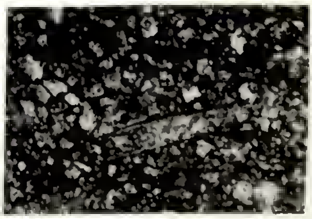

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PLATE 4

Burrows or Borings at Locality CL7 and Spicules

Figure 1. Burrows at Locality CL7 in burrowed-dolomite facies, ruler is 15 cm long.

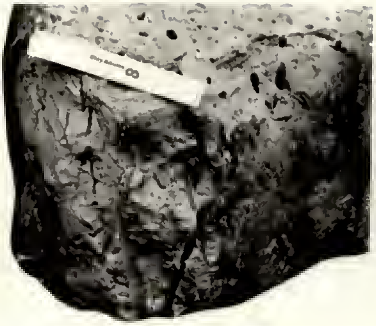
Figure 2. Oblique section showing spicules in calicle lumina (a), kaolinite filling calicles (b), drusy calcite lining calicle interiors and sparry calcite filling voids left by drusy calcite (c); Specimen number CM1-F42.

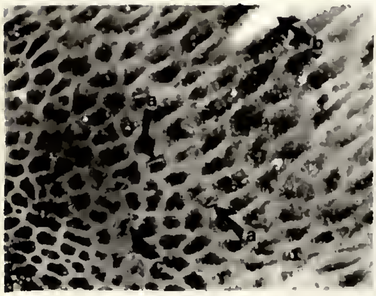
Figure 3. Enlargement of Figure 1 showing spicule (arrow).

Figure 4. Matrix around chaetetid mound showing pseudomorphs of siliceous spicules; Thin section number CM1-1.

Figure 5. Calicle wall and tabulae showing holes in wall possibly from dissolution of spicule (arrows); SEM photograph of specimen number CM1-F32.

1





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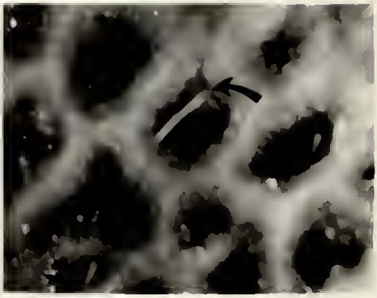

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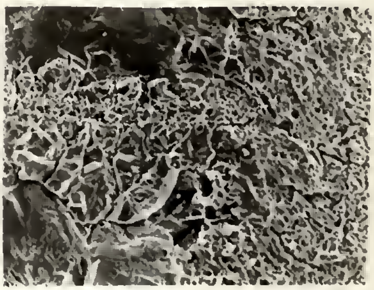

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Plate 5

Gross Morphology of Chaetetids from Southeastern Kansas

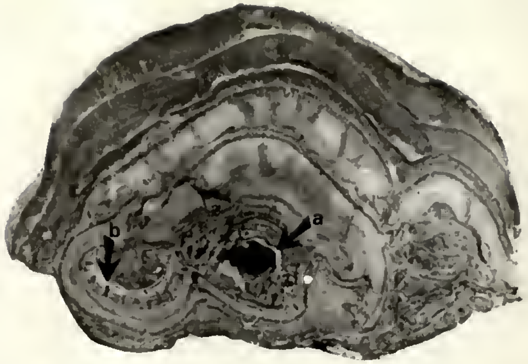
Figure 1. Shingle-form chaetetid showing oncolites as a substrate (a) and burrowing features in oncolite (b); polished surface of specimen number CM1-F46.

Figure 2. Interpretive sketch of Figure 1 showing five shingles of chaetetids (a through e) and multiple substrate of oncolites (f).

Figure 3. Mound-form chaetetid showing surface cracks (arrow); slabbed specimen number CL6-F2.

Figure 4. Column-form chaetetid from locality CM1; specimen number CM1-20.

1



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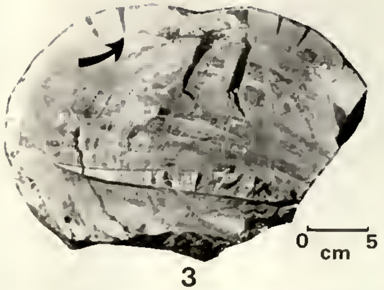

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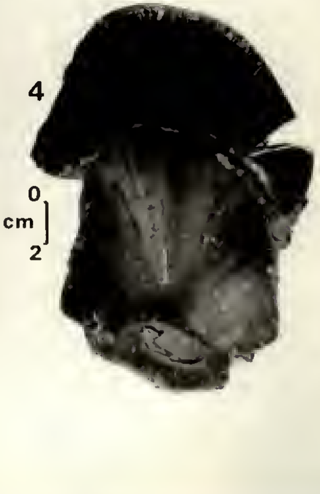


PLATE 6

Calicle Cross Sections and Astrorhizae

Figure 1. Surface of chaetetid showing, calicle lumen (a), tubercles at intersection of calicle walls (b), skeletal deformation by worm tube (c), and coenenchymal growth of chaetetid in upper left 1/4 of photo (compare with figure 11c of text); surface of specimen number CM1-21.

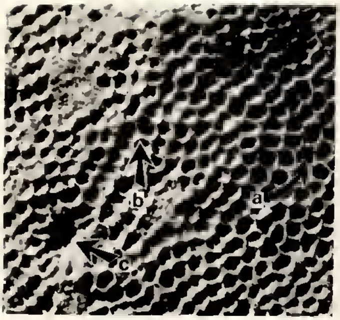
Figure 2. Cross section of calicles showing enlargement by longitudinal fission (arrows), irregular shape of calicles and sparry calcite filling calicle interiors; Thin section CL7-11.

Figure 3. Calicle cross section at intersection of walls showing granular wall structure and tabulae: SEM photograph of specimen number CM1-32.

Figure 4. Surface of chaetetid showing two closely spaced astrorhizae (a), erosion of top of chaetetid (b), and large fracture on chaetetid surface (c); surface of specimen number CM1-22.

Figure 5. Close-up view of astrorhizae in Figure 4.

Figure 6. Astrorhizae formed by linearly arranged calicles below the surface of the chaetetid (arrows); polished surface of specimen number CM1-F1.



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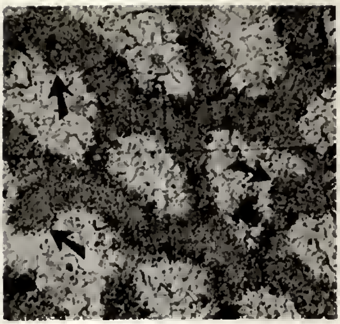

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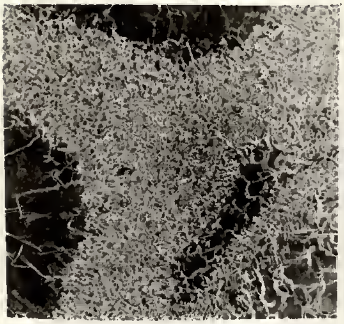

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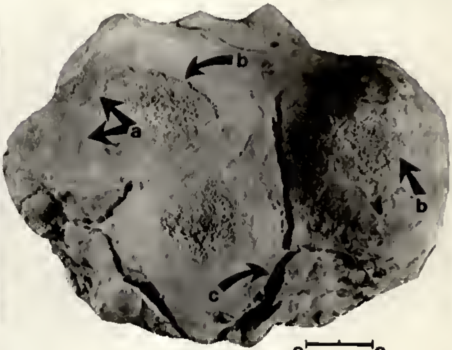

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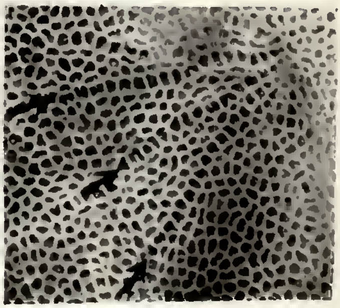

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PLATE 7

Growth Bands, Calicle Division and Wall Structure in Chaetetids from Southeastern Kansas

Figure 1. Longitudinal section of chaetetid skeleton (dark area) showing fibroradial structure, irregular wall structure, incomplete tabulae (arrow), sparry calcite filling calicle (light area), and spacing of tabulae; Thin section of specimen number CM1-F18.

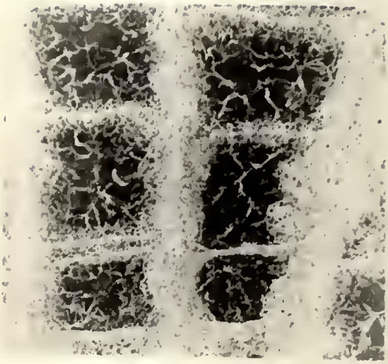
Figure 2. Longitudinal section of chaetetid skeleton (light area) showing granular calcite wall structure and tabulae continuous with calicle walls, and sparry calcite filling calicle (dark area); SEM photograph of specimen number CM1-F32.

Figure 3. Longitudinal section showing interruption partings (a), kaolinite filling of calicle (b), patchy silicification (light patches), tabulae spacing and calicle decrease (c) (reduction in number and size of calicles); polished surface of specimen number CM1-F45.

Figure 4. Longitudinal section showing longitudinal fission of calicles (arrow) and lack of tabulae in this column-form chaetetid; polished surface of specimen number CM1-20.

Figure 5. Longitudinal section of calicles showing growth bands (a), interruption partings (b) and kaolinite filling calicles (light areas within calicles); polished surface of specimen number CM1-45.

1



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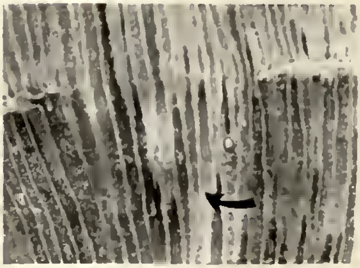

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PLATE 8

Symbionts and Chaetetids as Substrates

Figure 1. Chaetetid showing barnacle borings (arrow) and surface fractures; surface of specimen number CM1-20.

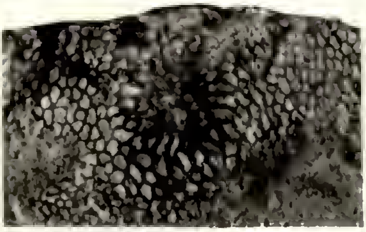
Figure 2. Longitudinal section of chaetetid showing skeletal deformation around worm tubes (arrows) and interruption partings; polished surface of specimen number CM1-F46.

Figure 3. Skeletal deformation around a "worm tube" on chaetetid surface; surface of chaetetid specimen number CM1-19.

Figure 4. Oblique section of boring structure in chaetetid skeleton; polished surface of specimen in sample CL6-B from core.

1

2



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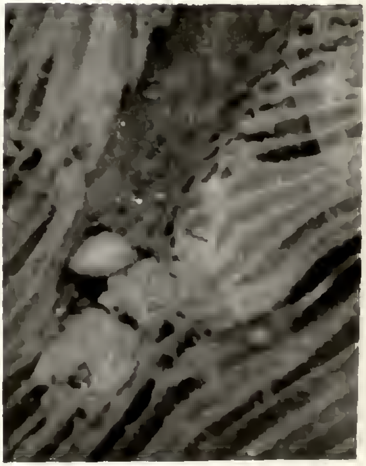

4

CHAETETIDS AND THEIR PALAEOENVIRONMENT IN THE AMORET LIMESTONE MEMBER (DESMOINESIAN) OF LABETTE COUNTY, KANSAS

by

JAMES E. MATHEWSON

B. S., Kansas State University, 1971

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1978

ABSTRACT

Chaetetids are the major biotic component of the Amoret Limestone Member of the Altamont Formation (Marmaton) in southeastern Kansas. Detailed study of the Amoret at three localities in southeastern Kansas revealed four facies: 1) transition, 2) chaetetid-algal, 3) burrowed-dolomite, and 4) oncolite-brachiopod. Chaetetids are ubiquitous in the last three facies.

These Middle Pennsylvanian chaetetids show an even closer relationship to sclerosponges than has been previously suggested by Hartman and Goreau (1972). Similarities include: 1) general morphology and spatial distribution, 2) size, shape and arrangement of calicles, 3) spicules, 4) tubercles, 5) calicle wall morphology, 6) skeletal accretion, 7) wall microsturcture, 8) astrorhizae, 9) growth banding, and 10) symbiotic associations and related skeletal deformation.

Chaetetids inhabited low intertidal to high subtidal, well lit, moderately turbulent marine waters whereas sclerosponges are confined to cryptic habitats or the deep fore-reef regions of the Caribbean, Coral Sea or South Pacific.